DOCTOR OF PHILOSOPHY

The Development and Use of Non-Screen Based Interactive Textile Objects for Family Communication

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The Development and Use of Non-Screen Based Interactive Textile Objects for Family Communication.

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For my boys, may we never be apart.

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Finally, I would like to thank my whole family, especially my husband Brian and my two children Zack and Ethan, for the time, encouragement and the belief that I could realise this research.

AUTHOR'S DECLARATION

This is to confirm that Joanne McNicoll is the author of this thesis. Unless otherwise stated, the author has consulted all references cited. The work, of which this thesis is a record, has been created solely by the author, and this research not been previously accepted for a higher degree.

Joanne McNicoll (Author)

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ABSTRACT

In this modern landscape where families are spending increasing time living separately, due to parental separation, work travel, and illness, current communication technologies do not fully support the needs of intimate family communication in families with young children, aged two to nine.

Prolonged separation, without intimate communication, can damage parent and child relationships, impacting on intimacy, bonding, and a child's mental health and wellbeing. Care and play activities are the main methods used to build bonds between parent and child. These are hard to replicate with ubiquitous communication technologies when families are separated.

Ubiquitous technology, such as the telephone, is easy to use but does not offer engaging ways for a child to interact. Skype (video call), has a higher potential for engagement due to its multimodal nature (audio and visual), therefore is more emotionally expressive. However, to 'Skype' someone, a child requires adult support, as the technology is more complex to use than that of a telephone. Thus, neither the telephone or Skype fully meet family needs for communication.

Parental-child separation was looked at within parental separation, work travel and illness, to explain how intimacy can be achieved through technology mediated communication systems. Following a Participatory Action Research methodology, utilising methods such as co-design, co-creation, and participatory design, the research discusses five small-scale studies as well as the Trace project, which was the main study of this research.

This research addresses communication issues between families through textile-based communication systems which enable intimacy and bonding. It highlights the importance of intimate communications and offers a list of preferred modes of communication for scattered families (multimodal disparate objects that allow for synchronous or

asynchronous communications with either the same modes or different modes of input and output). It also outlines key methods for designing new technologies suitable for use in family research (inclusive methods such as co-design, co-creation and participatory design). A better understanding of the participant families' emotional needs was achieved, by allowing them to become active participants at every stage of the design process (planning, acting, observing, and reflecting), thus producing considerate technologies for remote family communications.

AUTOBIOGRAPHICAL STATEMENT

This research is at the interface of participatory experiences, co-design and the impact of communication technology on family life in the 21st Century, but what led me here and why?

From 2002-2006 I undertook an undergraduate degree in printed textile design at Duncan of Jordanstone College of Art and Design (DJCAD), University of Dundee. Surrounded by lengths of fabric, dyes, squeegees, and screens I became fascinated, and indeed gained vast knowledge and technical skills relating to craft, cloth, colour, and pattern. The happiness and joy of being in the print room, undertaking practical tasks along with learning through making, allowed for a highly focussed state of mind (Csikszentmihalyi, 2004). This idea of thinking through making, along with learning practical textile design skills is still very relevant and important in the research and teaching that I do today.

However, it was not until I returned to the University of Dundee in 2008-2009 to study for my Masters of Design that I began to understand the true value of design and what a designer could offer. Design became more than a personal exploration of colour, pattern and placement, resulting in beautifully designed objects. The realisation and understanding of new methods and how other design disciplines operate offered a different approach of designing for me, using the same practical methods and processes that were familiar but in a whole new way. My role as a designer changed, utilising systems thinking and new design methods to tackle complex design problems focussing on people, communication, and

wellbeing over aesthetics. The pieces I was creating had a secondary social purpose as well as a practical or aesthetic one. Through my research and design work I was no longer a sole practitioner, I became a mediator, facilitator, and a visualizer producing quick and less polished prototypes that held the ability to convey an idea or help communicate important information and emotion in a way in which my earlier work was lacking. This new way of looking at design was a revelation, and sparked my interest in research allowing me to explore my curiosity surrounding communication. No longer was I focussed on the creation of beautiful textiles for the sake of fashion, but began experimenting on how I could use my subject, skills, and the knowledge of craft to solve real world problems. My Masters work allowed me to explore personal barriers in uncomfortable social situations through creating oversized garments, printed with thermochromic and photochromic pigments (temperature and UV light reactive inks), that invited outsiders into the wearer's space. Conversations and physical touch were encouraged through a playful exploration of the body triggering colour change (appearing and disappearing prints) through stimulation to heat (hugs, rubbing, touching, and blowing) and UV light sources (sunlight or UV lamps). I was invited to exhibit the work at the New Media Scotland Cryptic Night's Event at the Centre for Contemporary Arts, Glasgow (July 2009).

The expertise and new understanding of design thinking, developed throughout my Masters enabled me to gain a position as a KTF (Knowledge Transfer Fellowship) researcher. I worked with a technical textile company, Tayside Police, and the University of Dundee, researching the movement, comfort and protection of ballistic wear for police officers. The role entailed the facilitation of co-design workshops with police officers, prototyping of ballistic vests, and being the interface between academia, industry and service.

In 2010, I was successful in securing AHRC funding to undertake a PhD study into co-designing family communication objects and systems. By looking at conceptual and marketable products and systems relating to remote communication, a clear gap began to emerge around child communicators. There was little research or product development being done looking specifically into designing communication devices for young children (aged 2-8) who were not simplified adult communicators. This, to me, was surprising, as at

the time of initial research I had a 3-year-old niece and 6-year-old nephew and have since gone on to have my own children (aged 3 and 5), so I understood the nuances of family communication and saw the need for parent and child communication objects and systems designed with modern family life in mind. I had a clear understanding of the importance of family bonding and staying connected not only from my own family experiences but also through the knowledge gained between my undergraduate and post graduate study, where I worked in a children's nursery. These experiences gave me a wide understanding of early years care, play and communication, as well as a sound grounding in varying family life along with separation circumstances such as work, illness, divorce, and adoption.

In October 2013, I had the opportunity to become a research assistant on the BESiDE research project within the School of Computing at the University of Dundee. This role allowed me to further my knowledge of co-design, through the planning and running of co-design workshops, within the multidisciplinary research team. The role allowed me to work with another vulnerable user group, elderly users in a care home setting.

Currently, I am working for the V&A Dundee, as the Design for Business Research Manager, in the Design for Business Programme. An innovative programme that uses design thinking to support business growth, development and sustainability.

CHAPTER 1: Introduction

> "*Communication plays a central role in our lives. In fact, being a skilled communicator enhances one's prospects for sustaining a happy, healthy, and productive life.*"
> (Burgoon, Guerrero, and Floyd, 2016, pxiii)

1.1 Introduction to Research

Our utilisation of technology elevates us to being the most intelligent form of life on earth and has helped to shape human existence. (Judge and Neustaedter, 2014). It is a collection of knowledge and skills used by the world to improve and enrich people's lives. It ranges from the knowledge to convert natural resources to basic tools to help communities provide food and shelter for their families, to the process of sharing complex communications over distances. Today, technology is truly ubiquitous.

However, while technological advances over the past 100 years have given us the ability to communicate (either virtually or physically) through phone, the Internet, and fast affordable travel, these advances have compromised the quality of the communication. Perhaps diluting the meaning and emotions behind certain interactions (Freeman, 2009), and "*our prospects for happy, healthy lives depends on how well we communicate*" (Burgoon, Guerrero, and Floyd, 2016, p1).

Technology is the "*science of craft*" (Liddell and Robert, 1980, p184). Yet, modern day technology design is perceived as being mostly concerned with machinery, factories, and computers for efficiency in the workplace (industry, construction of products), or focussed around communication devices such as smartphones and computers, targeted for the adult consumer market.

Technology can be problematic, and can occasionally detract from, rather than enhance our lives and wellbeing. It is evident in many current communication technologies, that they can lack the emotional intelligence required to facilitate intimate communications (i.e. social media, text messages, email). Often, they leave users distant and isolated from each other by the manner in which they work, such as social media's sharing of everything and nothing all at the same time (Slater, 1990). Thus, it is how technology is used to enhance and nurture human life and wellbeing that is the key to the success of a technology, and not the complex nature of data transmission (Liddell and Robert, 1980).

As we move further into the 21st Century, families are becoming more scattered (Cheok, 2010, and Yarosh, 2012). Finding a work life balance often leaves parents concerned with their children's wellbeing (Cheok, 2010). Work travel, divorce, and even illness, means parents are often separated from their children for long periods of time. This physical separation can result in children living between homes or in full time childcare. This can result in their routines, daily care and play responsibilities being managed by nurseries, child minders and extended family, while parents juggle work commitments to remain solvent.

The scattering of 21st Century families results in the use of communication technologies to replicate physical communication (Flango, 2003). The telephone and Skype are the preferred choices per Bakeman and Brown (1980) and Abowd, Gauger and Lachenmann, (2003). However, this type of communication can cause issues for young children, due to the lack of physical intimacy, essential for children to bond, feel safe, loved and secure (Bakeman and Brown, 1980 and Cheok, 2010). Young children especially (age birth to nine), need constant love, care and guidance (Falicov, 1995). These children have difficulty in understanding the separations caused by family scattering, as well as "*the true meaning of words spoken by their parents*" through these preferred communication technologies (the telephone and Skype) (Cheok, 2010, p161). Thus, families are seeking out new ways to communicate, replicating the physical intimacy and touch (i.e. through tactile exchanges such as kissing, hugging, tickling, holding hands) that is lost due to their separations (Cheok, 2010 and Yarosh, 2012).

Consequently 21st Century families are looking for other methods of communications, both synchronous and asynchronous (see Chapter 2 Section 2.3.1.2), that will allow them to communicate more effectively when apart (Yarosh, 2012). Many of these methods utilise the adopted technology used within family communication such as the telephone and Skype (Harmon, 2008 and Conlin, 2009), however, this isolates families from the "*real world where actual physical touch is very important as a communication means*" (Cheok, 2010, p161).

Since growing research into the use of technology for communication is predominantly quantitative, younger children (aged two to seven) are being left out, despite their growing use and understanding of these technologies (Ólafsson, Livingstone and Haddon, 2014). This thesis explores current communication technologies and research surrounding the growing area of family communications. Five qualitative small scale-studies were undertaken (Chapter 4), with twenty different families who face separation due to work, illness or family breakdowns to understand their issues with current family communication. These small-scale studies culminated in the main study, the Trace project (Chapter 5), which worked with three families (including children aged four to twelve) to co-design personalised family communication systems.

1.2 Research Question, Aims, and Objectives

1.2.1 Research Questions:

RQ1: Can wearables and smart textiles aid intimacy within family communication systems?

RQ2: What is the role of co-design in the understanding and creation of such a system?

1.2.2 Research Aims:

1. To explore the potential of wearables and smart textiles within family communication systems.

2. To explore the integration of intimacy, within family communication systems through play.

3. To explore the potential of disparate but connected communication objects within family communication systems.

1.2.3 Research Objectives:

1. To facilitate intimacy through family communication systems using wearable technologies and smart textiles.

2. To identify suitable methodologies and methods to be used within family research.

3. To develop recommendations for modes of communication and communication objects within family communication systems.

1.2.4 Shifting Research Questions

Due to the chosen methodology, Participatory Action Research, the research questions evolved as the research unfolded. This was due to the participant driven nature of Participatory Action Research, where a researcher embeds themselves in a community (in this case families), with a general idea of an issue they are facing (communication/separation) but needs further information from the community to uncover the true problem and form a clear hypothesis. Thus, the aims, objectives and research questions are driven by the community, as they become active researchers within the project. Methods of data collection and analysis are also determined by the communities, as the researcher gains understanding and empathy for said community by listening and observing their sayings doings and relating's. Thus, a Participatory Action Research methodology can uncover latent needs within a community, which would be difficult to discover without this immersive approach.

The original set of research questions were as follows:

> ***RQ1*** - What is the potential of textile-based objects, integrated with wearable technologies, to facilitate thoughtful and emotive communication over distances between parent and child?
>
> ***RQ2*** - How can these exemplars of textile-based communications embody empathy for the user when communicating emotions to the parent and child? What is the real need for disparate objects and what would be the information, that each parent and child, needed to feel emotionally connected?

It was determined through discussion with the families that creating intimacy through both the making and the using of the communication objects and systems was key to family bonding and the sustaining of family relationships whilst apart. This resulted in the final set of research questions set out in section 1.2.1.

1.2.5 A Qualitative Approach

This thesis discusses several studies which used a qualitative research approach to data collection. These include five small-scale studies (see Chapter 4) and a main study, the Trace Project (see Chapter 5). Twenty different families were engaged within the research over a four-year period (2011-2014), three of which took part in the main study. This offered five groupings for user testing within the main body of research (the Trace Project), two from Family A, two from Family B and one from Family C.

Marshall *et al*. (2013), questions researchers abilities to dedicate adequate care when analysing and reporting exhaustively providing 'rich content' for studies containing forty or more interviews. This according Robinson (2014) can cause 'analytical overload'. To prevent this from happening Robinson suggests combining numerous "*separate studies together into larger syntheses*" (2014, p 29). This allows for larger groups to be analysed individually then pulled together into key themes and codes to gain a wider view of the data.

Taking Marshall *et al.* (2013) and Robinson (2014), into account, forty interviews (mainly unstructured conversational interviews, see sections 2.8.1.2 Use of Interviews, 5.4 Process, 5.4.5.1 Use of Interviews within the Trace Project and 5.7 Analysis), were conducted throughout the research, which spanned from 2011-2014. Twenty-five interviews within the small-scale studies, and fifteen interviews within the main body of the research, the Trace Project (see Chapter 5, and Appendix 4.10 for interview transcripts and a list of interview questions/topics).

> "*the best and most rigorous justification for sample size of interviews does not emerge from the steps a researcher takes in collecting the data (process-driven), it emerges with statistical demonstration of redundancy in codes (results-driven)*"
>
> (Marshall *et al*. 2013, p 20)

Thus, sample sizes were be driven by the data collected. When the data collected (families sayings), from the interviews were repetitive, no new insights were gained, meaning data saturation has been reached. Thus, offering adequate numbers of participants sayings for analysis. Through the small-scale studies, a saturation point was reached, with repetition of sayings and themes coming from the interviews and responses to communications and object choice. Thus, three families were chosen with different separation circumstances (work travel, divorce and illness), to offer varying perspectives on communication and separation needs within the main study, the Trace Project.

1.3 Thesis Structure

Chapter 2. *Literature & Contextual Review*: outlines literature within the following areas:

The 21st Century Family (Section 2.2) exploring the changing needs of family communication as family dynamics continue to shift and we move further into the digital age.

Communication (Section 2.3) exploring the purpose of human communication, outlining types of communication such as: *Soft and Hard Communication* (Section 2.3.1.1), and *Asynchronous and Synchronous Communication* (Section 2.3.1.2), as well as *Communication Theory* (Section 2.3.1.3).

Sociology of Family Relationships (Section 2.4) looks further into family dynamics, family communication needs, and outlines the need for both *Intimacy* (Section 2.4.1), and *Play* (Section 2.4.2), within family communication systems.

Technology Mediated Communication (Section 2.5) outlines positive effects of *Technology Mediated Communication*, as well as the concerns surrounding this type of 'non-physical' communication for use in family communication among family members. It also explores research in disciplines such as *HCI* (Section 2.5.1), and *Wearable Technology & Smart Textiles* (Section 2.52), offering context for this research into family communication, from a design-led perspective.

Participatory Action Research (Section 2.6) is a Participatory Action Research (PAR) methodology, exploring *Collective Creativity* (Section 2.6.1), *Established Methods & Methodologies in textile design* (Section, 2.6.2), which outlines and discusses the reasoning behind the methodology and method choice for family research, and the importance of family participation, when designing objects, systems and services that will directly affect their daily lives.

Summary of the Literature (Section 2.7) summarises the literature discussed within this chapter and highlights the key knowledge gained, which was then used to develop the methodology, the small-scale studies, and the main study of research discussed in this thesis.

Chapter 3. *Methodology*: introduces the methodology used in this thesis, which was Participatory Action Research (see *Research Strategies*, Section 3.2).

The Methodology: outlines the purpose and how *Participatory Action Research is used in social research* (Section 3.2.2), looks at the *Participatory Action Research Process* (Section 3.2.3), the *Ethics* within a Participatory Action Research process (Section 3.2.4), *The Research Methodologies and Methods Adapted in this Thesis* (Section 3.3), outlining *Why Participatory Action Research is Suitable for Family Research* (Section

3.3.1), identifying the *Methods Used in this Thesis* (Section 3.3.2), and the types of *Data Analysis* used (Section 3.3.2.5), *Thematic Analysis* (Section 3.3.2.5.1). This chapter concludes with a *Discussion* (Section 3.4) of the chosen methodology, and methods and how they were adapted and used throughout the thesis.

Chapter 4. *Small-scale Studies*: outlines the five small-scale studies conducted in the first two years of study. These were as follows:

Study 1 - *Pigeon Post* (Section 4.3) used RFID technology to tag plush toys, or small hand-made textile objects, that allowed children to independently navigate the Internet, i.e. accessing Flicker photo streams, favourite websites, YouTube videos, and place Skype calls to their family members without any intervention. This project was undertaken with five families (three separated by work travel, and two separated by parental separation).

Study 2 - *Skyping Scarf* (Section 4.4) used RFID technology and QR codes, sewn or hand-printed onto personalised scarves, allowing the wearer to place a Skype call to a family member. This project was undertaken with four families (two separated by work travel, and two separated by parental separation).

Study 3 - *Message in a bottle* (Section 4.5) was a design probe, deployed to six different families (two separated by work travel, three separated by parental separation, and one separated by child illness), which used lo-fi artefacts (artefacts with no working technology, made from basic materials such as paper, card), play, self-reporting, and diary studies to discover how the families communicated when apart, whilst allowing the families to 'dream' how they would like to communicate, bringing them further into the design process.

Study 4 - *The KIST project* (Section 4.6) used RFID technology and QR codes, sewn or printed onto personalised artefacts made at two co-design workshops at the Children's Hospice Association Scotland (CHAS). The artefacts allowed children

who visited CHAS for hospice care to communicate information about their life to CHAS staff, other inpatients, and their family. The personalised artefacts were made during the two co-design workshops, with six different families who were all separated at times by child illness. These artefacts were made to allow the children who visit CHAS for respite care to be in control of their communications. Most of these children had complex communication needs; many have little or no speech, limited motor skills, and often cognitive impairments, which can make communicating difficult. The artefacts offered the children a level of control over their communications, and what information about their personal lives they wanted to share. Children could 'gift' objects to CHAS staff and other inpatients that linked to online content, such as favourite songs, cartoons, family pictures and other personal information that could help new people in their lives understand their personalities and needs.

Study 5 - *Smart Networked Toys* (Section 4.7) used lo-fi prototyping techniques and no working technology, in co-design workshops, with four families (one family separated by work travel, two families by parental separation and one family by child illness), to discover what a child's communication object could look like (if made of soft fabrics instead of hard plastics), and what types of interactions would be desirable for family communications.

The five small-scale studies offered insights into the rationale behind the choice of methods, the means of collecting information, and the growth of trust between the researcher and the participating families. The key learning from each small-scale study led on to the Main Study (Chapter 5; *The Trace Project*).

A breakdown of the twenty different families who were involved in this research (through the small-scale studies and main study), can be found in Chapter 4, Section 4.1, Table 4.1.

Chapter 5. *Main Study; The Trace Project*: outlines and discusses the main study of the research, the Trace communication system.

The Trace communication system is a two-way family communication system that allows adults and children to communicate with each other whilst they are apart. The adult interacts with the system via an app on their phone (unobtrusive if they are working) whilst the child communicates via a bespoke communication object (toy) that they have helped to design through a series of participatory methods (co-design workshops, interviews, diary studies).

The Trace Project highlights and discusses the advantages and disadvantages of alternative ways to connect parent and child through co-designed personal communication objects. Trace is a unique and engaging project that integrates approaches from textile design, interaction design, and service design.

The Trace Project was awarded £7.5k, from an Alt-w fund (see Chapter 5, Section 5.3) to develop a family communication system, which was co-designed and tested with three different families, who all had varying separation needs; **family 1**; separation due to work commitments, **family 2**; separation due to child illness, and **family 3**, separation due to parental separation.

Chapter 6. *Conclusions, Contributions to Knowledge and Future Directions:* outlines the contributions to new knowledge created by the research.

Addresses the aims and objectives of the research. Discusses the research and makes suggestions for future research into family research and the co-design of family communication systems.

The main contributions to knowledge are positioned within design and technology research (See Section 6.2), through the identification of optimal modes of intimate family communication, and how these modes can be implemented, identifying suitable methodology and method selection within family research of communication systems, and further the applications of wearable technologies and smart textiles.

CHAPTER 2: Literature & Contextual Review

2.1 Introduction to the Literature

This chapter reviews scholarly literature around family and technology mediated communication. The themes identified from my research questions and which inform my aims and objectives are 1. The 21st Century Family (Section 2.2), and 2. Technology Mediated Communication (Section 2.6). These were chosen as it was essential to look outside traditional textile design practice methodologies, which tend to be practitioner focused, and rely on the practitioner's own tacit knowledge (Finn, 2010). Due to the limited nature of methodology that focusses on textile design research, a third area of literature was also explored, Design Methodology (Section 2.8 and Chapter 3 *Methodology*).

2.2 The 21st Century Family

During the past few decades, families have become more diverse and are continuing to break away from the two parent, two child family (Pitt-Catsouphes *et al*. 2015, Kuczynski, 2003 and Bott and Spillius, 2014), where the father was the 'breadwinner' and the mother was the 'homemaker'. These changes have become more apparent since the year 2000 (Bianchi and Milkie, 2010).

Families are increasingly 'scattered' (living apart) and 'blended' (made-up of biological and non-biological care givers), due to 21st Century living, which raises the question: what does a 21st Century family look like? The meaning of 'family' and 'home' are shifting (Bianchi and Milkie, 2010, and Roseneil and Budgeon, 2016). Families contend with pressures of modern day living, where supporting a family often requires a two-parent salary household, shifting gender roles (Pitt-Catsouphes *et al*. 2015), and relocating and traveling for work (Chandler, 1991 and McKee and Mauthner, 2000). This results in some parents working in different cities/countries part of the week and being 'home' with their family at weekends (Heath, 1999, Levin, 2004, and Dermott and Seymour, 2011). These economic

pressures combined with increasing divorce rates (Sweeney, 2010), the legalising of gay marriage in the UK except Northern Ireland (BBC News, 2014), and definitions of a 'family' extending to include, close friends and childcare providers (Roseneil and Budgeon, 2016, Dermott and Seymour, 2011, Strong and Cohen, 2013 and Pitt-Catsouphes *et al*. 2015), change our ideas and assumptions of what the 21st Century family looks like. The term 'blended family' was born in the 21st Century, this phrase encompasses the evolving make up of modern day families.

With the structure and make-up of families changing (through blending and scattering) so do the ways in which they communicate (Brown, Green and Harper, 2001 and Allan, 2017). Understanding the impact these changes have on family cohesion and the individual's communication needs is vitally important. This fast growth within society can leave people feeling lonely, isolated, and without value (Slater, 1990). This especially important for children who often live in blended homes, with a biological parent, step parent and step or half siblings (Roseneil and Budgeon, 2016, and Sweeney, 2010). This can be their full-time residence, or their 'home' may be split between their biological parents (Sweeney, 2010, Turunen *et al*. 2017, and Dermott and Seymour, 2011). As the meaning of home and family continues to blend, so too do communication technologies and how they are used to support communications (Brown, Green and Harper, 2001). Scattered families continue to communicate and emotionally connect when they cannot be physically together (Stern and Messer, 2009, Stafford and Hillyer, 2012, Bacigalupe and Lambe, 2011, and Ganong, Coleman, Feistman, Jamison, and Markham, 2012).

The Internet is one of the major technological developments in the last 100 years and it can facilitate intimacy in several different ways (Bell and Binnie 2000, and Valentine 2006). For example, the exchanging of information about thoughts and activities or "*knowing*", enabling flows of feeling and emotionally binding together dislocated lovers and family members or "*loving*", and Internet shopping for a grandparent, or telephone banking for a child or "*caring*" (Valentine 2006 and Valentine 2008). The Internet then does not produce new types of behaviour; it simply allows people to carry on with these behaviours remotely (Valentine, 2006 and Morgan, 1996).

It is important to recognise the positive and negative impact communication technologies can have on family life; and how families' communication alters when technology is introduced into the home (Nie, 2001,Watt and White, 1999 and Yarosh, 2012). The options for families to communicate has grown in the last 15-20 years from face-to-face, to landline telephones to mobile phones, email and Skype, extending communications to blended forms of spoken and written (Stern and Messer, 2009). These low-cost communication devices have allowed co-parenting for families faced with divorce and separation to have daily communication and information sharing, enabling decision making about the family and schedules (Lanigan, 2009, Stern and Messer, 2009, and Bacigalupe and Lambe, 2011). Technological advances such as these are advantageous for adults to share information about their children, allowing them to successfully plan and share care.

However, information and communication technology (ICT), use with children poses safety issues for both children and parents (Tsai *et al*. 2010). These systems may not be safe; strangers may connect with or contact children, and children can view inappropriate content online. Parents manage safety concerns by checking browser histories, restricting access and limiting use (Lenhart *et al*. 2007). Parental controls continue to be used minimising the risk; nevertheless, systems can be hacked or may not be secure, resulting in limiting children's independent use of such technology.

Worries with ICT usage are not solely associated with children and adolescents. Adult users can often have problems with their communications, with messages being misunderstood, due to the lack of verbal or non-verbal cues present. These types of misunderstanding can result in tension and conflict, upsetting family cohesion (Carvhalo *et al*. 2015, Huisman *et al*. 2012, Mesch, 2006, Watt and White, 1999 and Williams and Merten, 2011). When verbal and non-verbal cues are missing from communication, it is almost impossible for children, who have yet to develop emotional intelligence, and the understanding of successful communication (e.g. turn-taking, tone of voice, eye contact, facial expressions.), to successfully communicate with current screen based and audio-based technologies (Baron-Cohen, 2012 and Baron-Cohen, Lombardo and Tager-Flusberg, 2013).

Furthermore, Nie has shown through his 2001 study that people with higher levels of engagement with ICT, have lower levels of social engagement and reduced communication and interaction skills than those who do not use ICT as frequently (Nie, 2001 and Carvalho *et al*. 2014). Thus, the overuse of ICT communications prevents us from growing and developing essential face-to-face and interpersonal communication skills (Nie, 2001). This is a worrying realisation, as people with higher ICT usage tend to be of the younger generation, as they are surrounded by technology from an early age. Consequently, children and adolescents are becoming more confident navigating search engines and using social interfaces than they are with face-to-face interactions and communications, leaving them without essential 'real world' communication and interaction skills (Nie, 2001, Mesch, 2006 and Stern and Messer, 2009).

Positively, research has shown that ICT usage can increase the emotional bonds in families (Bacigalupe and Lambe, 2011, Chesley and Fox, 2012, Kanter *et al*. 2012, Lanigan, 2009, Stern and Messer, 2009, Stevenson, 2011 and Zhong, 2013) as well as the time spent together as a family (Carvhalo *et al*. 2015, Chesley and Fox, 2012, Devitt and Roker, 2009, Lanigan, 2009, and Plowman *et al*. 2010). Integration of ICT within the family home (see Section 2.6.1 *HCI*) is thought to strengthen family intimacy (Bacigalupe and Lambe, 2011 and Yarosh, 2012), allowing families to be 'present' with one another when not physically together (Aponte, 2009, Stern and Messer, 2009, Mickus and Luz, 2002 and Stafford and Hillyer, 2012). Engaging in online communication and activity (when directly associated with family communication), can have positive effects on family bonding and intimacy within the family unit (Yarosh, 2012).

However, if online activity takes family members out of the 'present' and away from face-to-face family time and real-world interactions, activities and play, it can have negative effects resulting in feelings of isolation and disconnection from the family (Williams and Merten, 2011). Baron-Cohen, et. al (1996) also states that if children do not learn how to play and interact, using both symbolic and pretend play (see Section 2.4.2 *Play*), they will find reading social situations and other people's intentions extremely difficult. This places importance on real world play and interaction over exclusively online learning and gameplay. It is thus important to explore how technology can be used to support family

communication through different stages of family life. Technology that will aid in supporting children to develop communication skills both online and offline is an area that needs further development, as most commercially available technologies are focussed on supporting adult/adolescent communications.

Parental bonds, now commonly referred to as 'attachment', speak of the special bond between a child and their primary care giver, normally a parent (Ainsworth, 1982 and Bell, 1995). The word intimacy (see Section 2.5.1 *Intimacy*), is also used to describe the 'special bond' that is present between parent and child (Blieszner, and de Vries, 2001, Battarbee, *et al*. 2002, and Jamieson, 2005). The word intimacy will be frequently used throughout the thesis to describe the types of interactions and communications that are sought by designed family communication systems. Attachment, through intimacy, is created between parent and child to ensure the survival of the child through nurturing and caregiving practices (Ainsworth, 1982, Bartholomew, 1990, Belsky, 1999 and Bell, 1995). The challenge for new communication technologies, will be how they safeguard these special bonds of attachment, and facilitate intimacy in the 21st Century family.

Per Baldassar (2008, p250), when families are apart they can 'long for' or 'miss' each other in the following ways:

1. ***Discursively*** - through words
2. ***Physically*** - through the body
3. ***Practice*** - through actions
4. ***Imagination*** - through ideas

Families, especially children demonstrate their longing for their parents through their bodies (e.g. crying), practically, through treasured objects (e.g. favourite toy), and through their ideas (e.g. telling tales of parents' adventures, to justify the separation) (Milton, 2002, Wilding, 2006 and Baldassar, 2008). Children do not often verbalise their feelings, as they do not understand their emotions or the vocabulary to express how they feel verbally (Baron-Cohen, 2012 and Baron-Cohen Lombardo and Tager-Flusberg, 2013).

Thus, the idea of 'co-presence' can enable families to feel connected when they are not physically together, and even when they are not in direct communication (Baldassar, 2008 and Baldassar *et al*. 2016). Baldassar (2008, p251), details four types of 'co-presence':

1. ***Physical*** - with the other person (face-to-face communication), using all five senses.
2. ***Virtual*** **-** telephone, Skype, email, and SMS messages (distant communication), using one or more senses.
3. ***Proxy*** **-** through an object or another person who embodies the spirit of the person (distant communication), using one or more senses.
4. ***Imagined*** **-** a feeling of togetherness when apart through daily tasks or routines.

When physical co-presence cannot be achieved, and virtual co-presence is not suitable for children's independent communication, proxy co-presence and imagined co-presence should be explored. This can allow children to feel connections through objects (e.g. security blankets, plush toys, favourite book), or imagined proxy (e.g. setting a place for a parent at an imagined tea party or including them during a bedtime prayer).

Humans are social creatures, needing connections, love and intimacy to nurture mental health and wellbeing, and ultimately survival (Pitt-Catsouphes *et al*. 2015, Galvin *et al*. 2015 and Burgoon *et al*. 2016). Thus, communication technology needs to embody a feeling of closeness and intimacy through the communication(s) and connection(s) they provide (Battarbee *et al*. 2002 and Yarosh, 2012). Cheok (2010) further argues that physical touch is an important means of communication and can better communicate intimacy and emotion than words or text can.

Thus, technology such as mobile phones, social media, Skype, instant messenger, that are becoming ubiquitous in facilitating communication, are no substitute for face-to-face communication. However, they can be utilised to compliment the blended family living apart or being separated by distance. Thus, technology can be a welcomed and valued tool, and in many ways, technology can extend intimacy (Holmes, 2004).

In the next section, we will review the types of communication technologies that are available, what the needs of the '21st Century family' are in terms of communication, and how a child's understanding and definition of 'home' and 'family' can impact on their developmental psychology as well as their close family relationships.

2.3 Communication

What is communication? Communication is everywhere, it is any "*information related behavior*" (Ruben, 1984), it is the "*sharing of ideas and feelings in a mood of mutuality*" (Dale, 1969), it is "*the transmission of information, ideas, emotions and skills...by the use of symbols*" (Berelson and Steiner, 1964) and the "*transmission of information, ideas, attitudes, or emotion from one person or group to another...primarily through symbols*" (Theodorson and Theodorson, 1969). Essentially communication is the flow of information, be that factual or intimate exchanges between two or more people. Communications have 'three elements', 1. The communicator, 2. the message, and 3. the receiver (de Mooij, 2014). Meaning is placed on the message by the communicator and the receiver, the message itself holds no meaning without context (thoughts, feelings, experiences) (de Mooij, 2014).

Communication, is essential in fostering relationships (Kuczynski, 2003, Burgess and Huston, 2013 and Galvin *et al*. 2015), maintaining relationships (Kuczynski, 2003, Allan, 2017 and Galvin *et al*. 2015), and essentially a fundamental skill that humans need to survive (Galvin *et al*. 2015 and Burgoon *et al*. 2016). From passing on vital information on how to grow and nurture food sources, the knowledge of foods which are safe to eat and those which are harmful, to the understanding of constructing safe and habitable homes (de Mooij, 2014), communication and the passing on of information is vital to human existence (Burgess and Huston, 2013, Galvin *et al*. 2015 and Burgoon *et al*. 2016).

Examples of human communication date back to prehistoric times and cave paintings, where symbols and pictures were used to tell stories and record important information (Whitley, 2009). Since then, humans have developed language, linguistics and other forms of communication media such as carrier pigeons, telephones, television and the Internet (Poe, 2010) (see Figure 2.1).

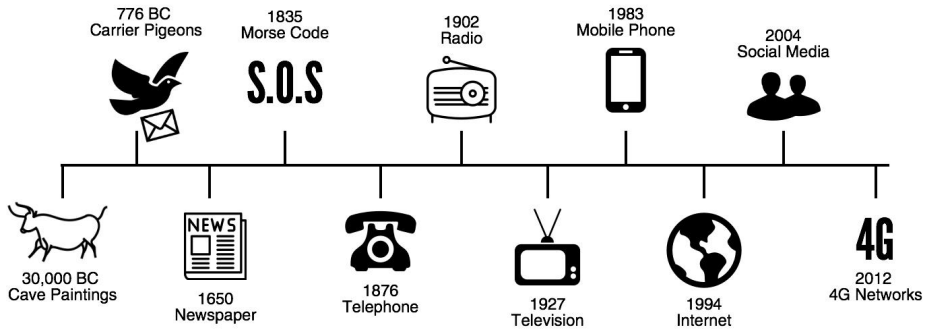

Figure 2.1 Timeline of Communication Technology (McNicoll, 2017)

Certain communications are suited to certain situations, and for communicating different information to different people. An email works well for work situations, while a phone-call or a text message may be more appropriate for personal communication due to the higher levels of perceived intimacy. These types of communications work well for adult communications but can fail to meet the emotional needs of children (aged two – nine) due to their complex nature (focusing on text or speech). Thus, new modes of communication are needed to support family communication.

> "*designing for parents and young children requires a different approach than doing so for friends or adult family members due to the asymmetry in goals and need between parent and child, the challenges posed by the cognitive and emotional limitations of young children, and the focus on play and care rather than direct communication.*"
>
> Druin (2009, p288)

2.3.1 Communication Types

The following sections (2.3.1.1 and 2.3.1.2) look at and discuss literature on current communications. Several methods of communication were identified through the literature and are used throughout the thesis to explain the modes of communication currently available through family communication systems. These were as follows; 1. Soft communications (seen as multi-sensory and intimate), 2. Hard communications (seen as predominantly non-intimate), 3. One-way communications (non-reciprocal), 4. two-way communications (reciprocal), 5. Asynchronous communications (non-immediate), and 6. Synchronous Communications (immediate).

2.3.1.1 Soft and Hard Communication

Hard communications are defined as communications that focus on textual or numerical data. The data that is sent and received is factual and predominantly non-intimate (business communications such as email and phone calls). Communication objects and systems that are 'hard' were designed for work situations and not for intimate communication (email, phone calls, Skype) (Druin 2009, Baym 2010, Yarosh, 2012 and and Neustaedter, Harrison and Sellen, 2013); their purpose being to relay information in a timely and efficient manner. However, it is possible to 'soften' these communications by the way they are used, e.g. language choice, using emojis or images, tone of voice (Wallace, 2007 and Druin, 2009).

Soft communications are defined as multi-sensory and/or intimate. Meaning they stimulate more than one sense at a time (sound and sight, sound and touch) (Yarosh, 2012), or offer the user a sense of 'home' or feeling of connection (Orta, Patrizio, Quinn, and Dellinger, 2003). Thus, 'soft' communications can offer more intimate communications, essential for building and maintaining of relationship bonds between remote parent and child (Druin, 2009, Yarosh, and Abowd, 2013). These types of communications offer feelings of closeness and intimacy, and do not always include factual data that is important to others, e.g. Pillow Talk (Little Riot, 2017) allows partners to hear each other's heartbeat in bed and know when their partner is 'present', this information fosters intimacy and connection for the couple, but holds no value to anyone else.

Both hard and soft communications, can be one or two-way communicators.

One-way communications display data through a single data stream. The information flow is one-way, meaning there is no feedback loop. Thus, no continuous interaction between users can be initiated through a one-way communication system. The lack of reciprocation in the exchange limits the nature of the communication, as data cannot be sent back through the same communication object it received. Families would need a third-party connector (a mobile phone for example) to generate, process, and send a new data stream containing the communication which would make for non-user friendly complex interactions.

Two-way communications are communications where the data is free flowing between two communication objects (classed as a communication system). Thus, information can be passed back and forth allowing for more interaction and connection between the users. Two-way hard communications are favoured within the business world due to the efficiency and immediacy of the communication. However, whilst these types of communications (phone calls, email, and video conferencing), offering text based, visual and sound communications, are well placed within professional relationships, they do not have the capabilities necessary to convey the intimate connectedness needed for family relationships (Baym 2010, and Neustaedter, Harrison and Sellen, 2013). Nevertheless, Wallace (2007) and Druin (2009), argue that the ways in which these technologies are used determines the intimate value of the communications. Studies such as The Share Table (Yarosh, 2012), Family Window (Judge, Neustaedter, and Kurtz, 2010) and Family Portals (Judge *et al*. 2011), show that intimacy can be achieved through these technologies within families. However, these tended to be tested with older children of seven years plus (Yarosh, 2012), or focussed on the adult connection (Judge, Neustaedter, and Kurtz, 2010).

Two-way hard communications can be used, by adults, in ways which offers the potential for intimate communications in adult relationships (through emojis, tone of writing, font size, bold, capital letters). Children cannot use these types of communications in the same way; due to the underdeveloped language and social skills, young children have comparable to adults. Communications through sarcasm, humour and that are text based, cannot be understood, due to the complexity of communication. Thus, two-way soft

communications, that are based on haptics, play and sound, offer the most potential, for creating family communication systems, due to the ages of the children (four to twelve years old). It was important that every child had the opportunity to understand and be involved in the design and use of the family communication system, especially the children aged four to eight, as there few communication technologies available to these children that do not require an adult's assistance to use.

2.3.1.1.1 Mapping Soft and Hard Communications

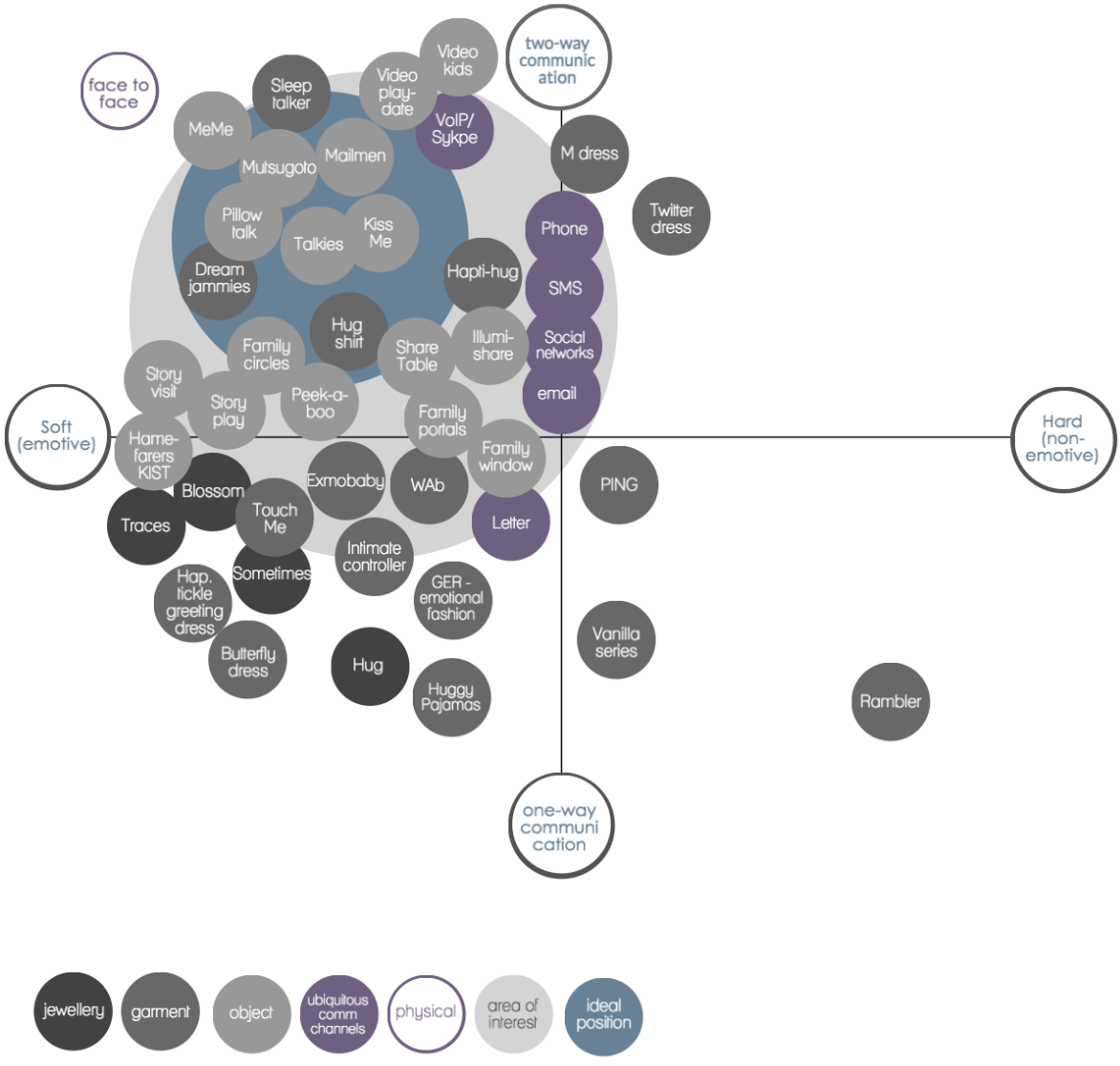

Figure 2.2 Map of one and two-way soft and hard communications (McNicoll, 2017)

The categorisation of communications (hard, soft, one-way and two-way) allowed the researcher to map out ubiquitous communication systems (commercially available) such as the telephone, Skype, social networks, as well as wearable and portable communications in contemporary practice through design research and thesis work in craft, product and interaction design. The communications plotted are numbered and a short synopsis of each can be found in Appendix 2, *Mapping Soft and Hard Communications.*

Skype calls are placed in the soft communication quadrant as they are a multimodal communication, mixing audio and visual communications, while phone calls, social networks, email and SMS messages are on the cusp between 'hard' and 'soft', because the way in which this technology is used, impacts the level of intimacy that can be created.

Letters and postcards are placed within the soft communication quadrant as they offer children a physical object to hold, and display on bedroom walls, kitchen fridges. Even though they are predominately text based (generally hand written), letters and postcards are usually accompanied by colourful images (on postcards), photographs, drawings or doodles, stamps, and postal franks. This information offers snapshots into the lives of the distant family member(s) and the experiences they are living, helping to maintain a sense of closeness and intimacy through the physical object(s) they are sending.

2.3.1.2 Asynchronous and Synchronous Communication

Asynchronous communications are communications (messages/interactions) happening at different times (i.e. not real-time), e.g. text message, email, social networks, where messages are not always responded to immediately or sometimes are unanswered completely (Figure 2.3).

Synchronous communications are communications (messages/interactions) happening in real-time e.g. instant messenger, phone calls, Skype. Synchronous communications always receive an instant response of some sort (audio or visual) and are more in keeping with an actual face-to-face interaction and conversation (Figure 2.3).

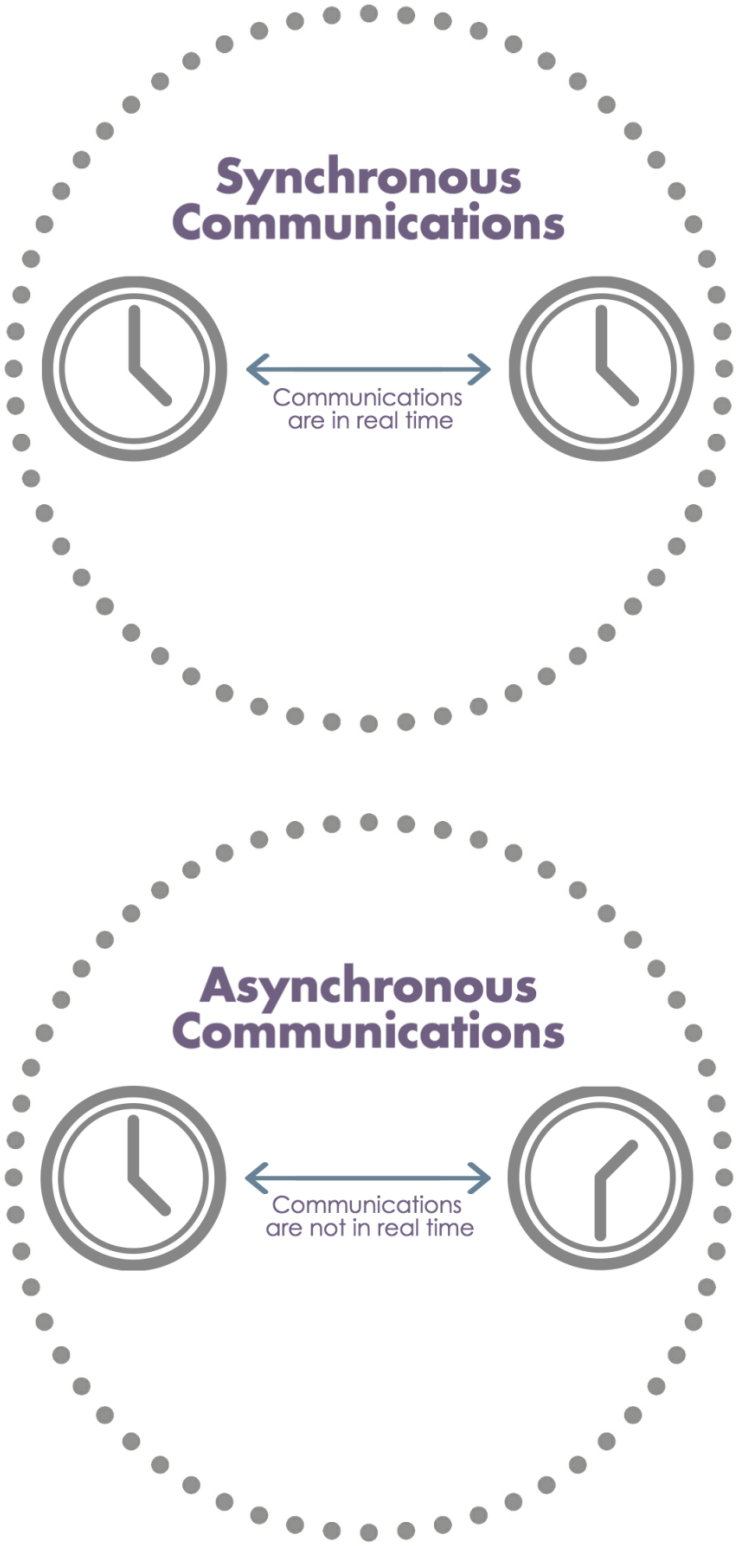

Figure 2.3 Asynchronous and synchronous communications and objects (McNicoll, 2017)

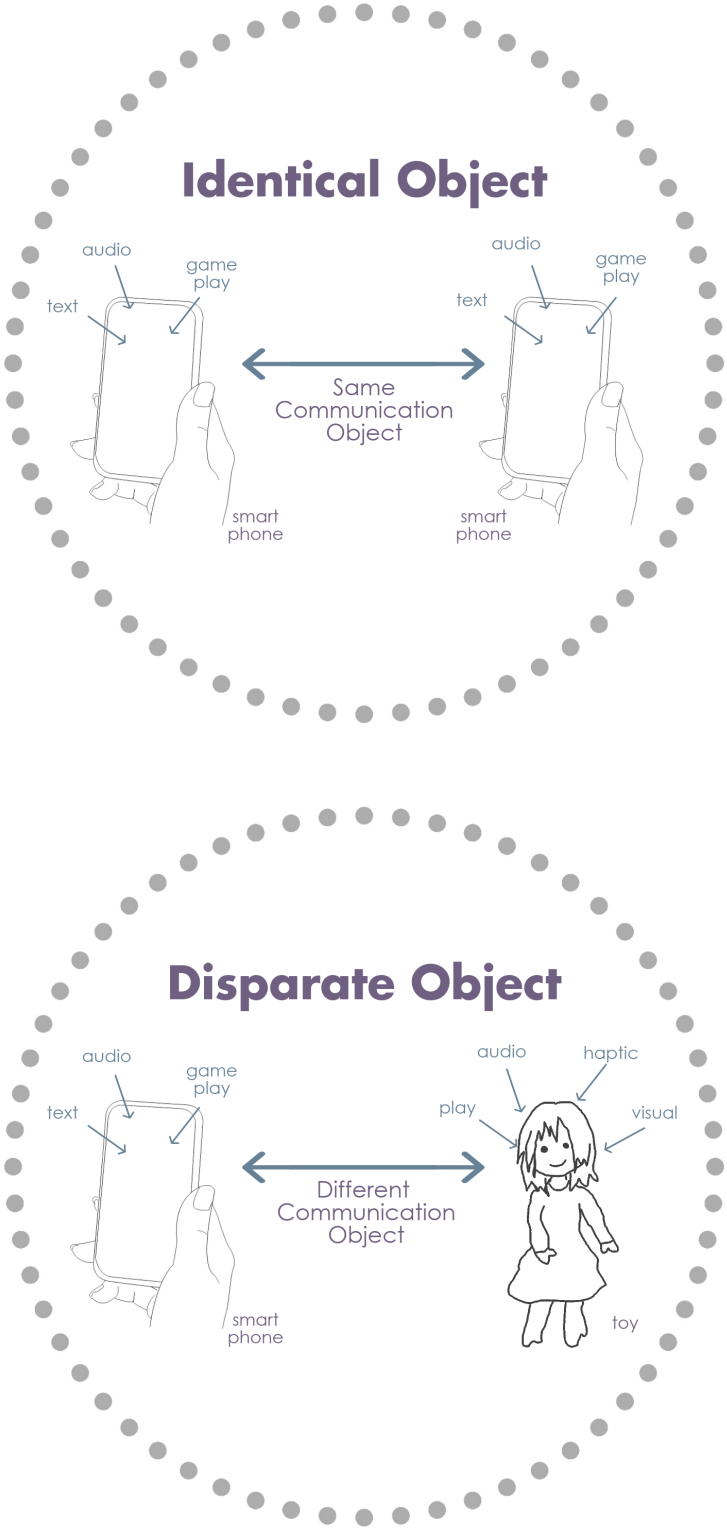

Figure 2.4 disparate and identical objects (McNicoll, 2017)

Disparate objects are different devices, objects or modes of communication (e.g. parent having a mobile phone and child having a toy). These types of communicators tend to be tailored to the individual's needs and situations, i.e. with the case of Huggy Pyjamas (Cheok, 2010), a small doll (parent's device) sends information to the child's pyjamas which receives the information and acts accordingly (Figure 2.4).

Identical objects are the same devices, objects or modes of communication used by both parties within the communication system i.e. mobile phone to mobile phone (Figure 2.4). Objects, whether synchronous (same types), or asynchronous (different types), both have the ability to offer synchronous and asynchronous communications.

Currently most soft communications for family use are focussing on synchronous communications and identical objects such as the Share Table (2012), Family Circles (2009), Family Portals (2011), Family Windows (2010), Story Play (2010), Story Visit (2011) and Peek-a-boo (2010); which utilise Skype, audio and location sensing technologies in considered ways which allow them to be used within these types of family communications, enhancing intimacy. Mailmen (2012), and Talkies (2017), are the only family communication systems that have been identified which offer families disparate objects (a toy for the child and an app for the parent), allowing them to better suit the alternate needs of the parent and child, while giving them a communication object that makes sense to them and offers them the interactions they require (Toymail, 2017).

Synchronous and asynchronous communications were explored as research shows both can have opportunity for intimate remote communications (Shotsberger, 2000). Both can replicate certain aspects of face-to-face conversations, such as 'turn taking' (Garcia and Baker Jacobs, 1999). Turn taking in conversation allows us to follow and understand the interaction, as information is provided in a chronological order. Verbal and physical cues are used in face-to-face conversations to indicate when one person has finished talking, prompting a response. While technology communications, such as phone conversations, text messages and email correspondence, cannot replicate both the verbal and physical cues used in face-to-face communication, it is possible to indicate turn taking. This is done in text

messages and emails, when a message is sent from one person to another, and in phone calls through verbal cues, such as pauses, questions or tone of voice (Gratier *et al*. 2015). The process of turn taking, as well as understanding family availability for communications is a difficult concept for children to understand (Plaisant *et al*. 2006 and Trevarthen *et al*. 2016). Often in face-to-face conversation children interrupt dialogue or miss social cues telling them it is their turn to speak (Sacks, Schegloff and Jefferson, 1974, Andersen, 1990 and Hatch, 1995). Because the awareness of turn taking in conversation is not developed until around the age of five (Hopper, 1992 and Gratier *et al*. 2015) asynchronous communications are useful for parent and child communications. Asynchronous communications have been found to be successful (i.e. SPARKS project, Brush *et al*. 2008), due to their non-immediacy. Grandparents could post messages or images when convenient, to be picked up "*whenever*" by the child offering flexibility within the communication (Brush *et al*. 2008, p638).

Synchronous communications, such as phone conversations and Skype calls are the preferred method of communication for 21st Century families due to the intimacy produced. Through these types of communications families can hear each other's voices and see each other's reactions which enhances the feeling of togetherness when apart (Ashkanasy, Benda and Vetere, 2007 and Cao *et al*. 2010). However, the inability to have synchronous conversations at times, due to availability (work meetings, travel, school) and time differences, makes asynchronous communications a necessity in remote family communications (Cao *et al*. 2010).

When immediate family communicate (from within the same time zone), 'adhoc' communications that happen frequently over the day are preferable over singular longer exchanges. This allows families to update each other on plans (i.e. when they will be home from work), and timings of communications (i.e. when they have meetings scheduled so cannot be disturbed) (Brush, *et al*. 2008, Cao et al., 2010). Hutchinson *et al*. (2003, p23), found through the interLiving project that not only do families want to synchronise schedules and 'check in' with each other during their day, they also want to "*have fun together, even at a distance*".

Toys offer the most potential as communication objects for children because of their play and haptic capabilities (Figure 2.4). They offer children a way to understand audio and visual messages in a way that makes sense to them and fits into their world of play and imagination (see Section 2.4.2 *Play*).

The child's experience can be enhanced through interacting with 'haptically-enabled' objects (toys). Haptic feedback can be used to mimic 'physical interactions' in a 'virtual environment', through playing with objects (Birnbaum et. al., 2017). Thus, haptic feedback is an important consideration when designing family communication systems, as it can bring the physical to virtual interactions, and is a way for children to receive feedback, without having to directly look at a screen (Tindale *et al*. 2014).

2.3.1.2.1 Mapping Communications

Figure 2.5 shows family communications mapped out depending on whether they offer asynchronous or synchronous communications (vertical axis), along with the same or different modes of input/output (horizontal axis). It highlights the primary area of focus for this research (bottom right quadrant), which offers different modes of input (different object/input device) with synchronous communications (real time), the secondary area of focus (top right quadrant), which offers different modes of input (different object/input device) with asynchronous communications (not real time) as well as where most research focussing on family interaction is being done (bottom left quadrant), which is synchronous input (same object/input device) and synchronous communications (real time). The bottom left quadrant (synchronous input and synchronous communications), is well saturated with research into family communication systems. The unification of parent and child communication objects (inputs) did not seem to offer families a cohesive communication system due to the differing needs of parents and children i.e. parents wanting to have basic information on health and wellbeing while the children need to feel connected and loved (Druin, 2009). Consequently, the research began to focus within the purple circle (bottom right-hand quadrant), showing different modes of input with synchronous communications, allowing the communications to be 'real-time' while the input / output methods (objects and available communications) could be very different, which would suit the ages and stages of the family members.

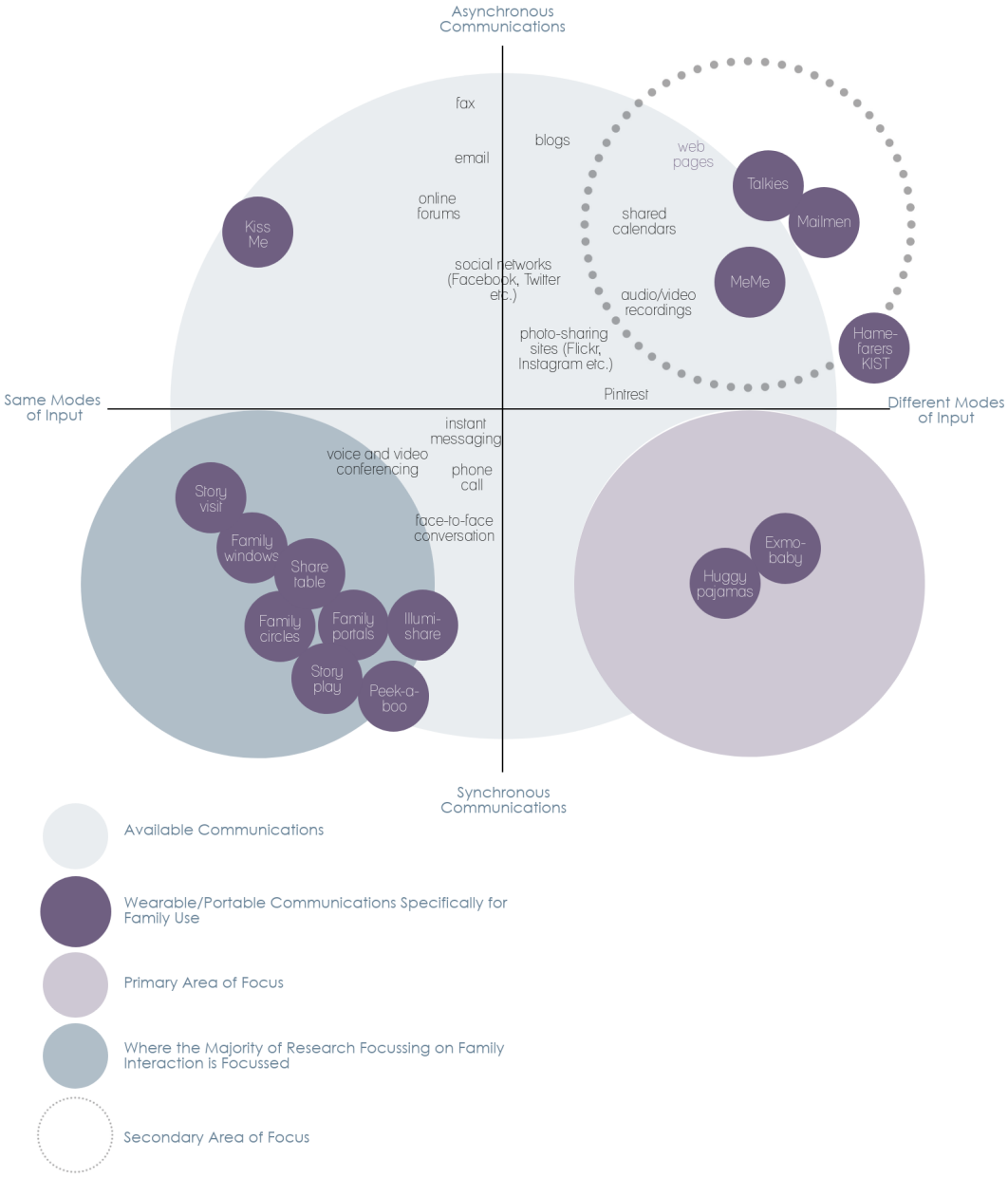

Figure 2.5 Map of family communications (McNicoll, 2017)

However, synchronous communications may not always be possible due to timings (work, school, time zones) thus, asynchronous communications with different modes of input (top right-hand quadrant), quickly became a focus for possible outputs within the research (Figure 2.5).

2.3.1.3 Communication Theory

Information theory (Shannon, 1948, Kolmogorov, 1956 and Reza, 1994), or as it is known in social science the Shannon-Weaver theory of communication (Shannon and Weaver, 1963, Pierce, 1980 and Hollnagel, and Woods, 2005), is a basic model of communication, that allows us to understand the basic principles of communication (Figure 2.6). It shows communication as a linear one-way process (Shannon and Weaver, 1963).

Communication systems such as the mobile phone and the Internet would not have been possible without information theory (Cover and Thomas, 2006). The Shannon-Weaver model of communication consists of a sender (information source), a message, a system (device) through which the message travels, a channel (ether) where noise/interference can disrupt or distort the message, a receiver (device), and a destination (recipient) where the message ends up (Shannon and Weaver, 1963, Pierce, 1980 and Hollnagel, and Woods, 2005). This model, allows us to understand the flow of communication from the information source to the receiver and interruptions to the message that could distort or confuse it (i.e. the noise source).

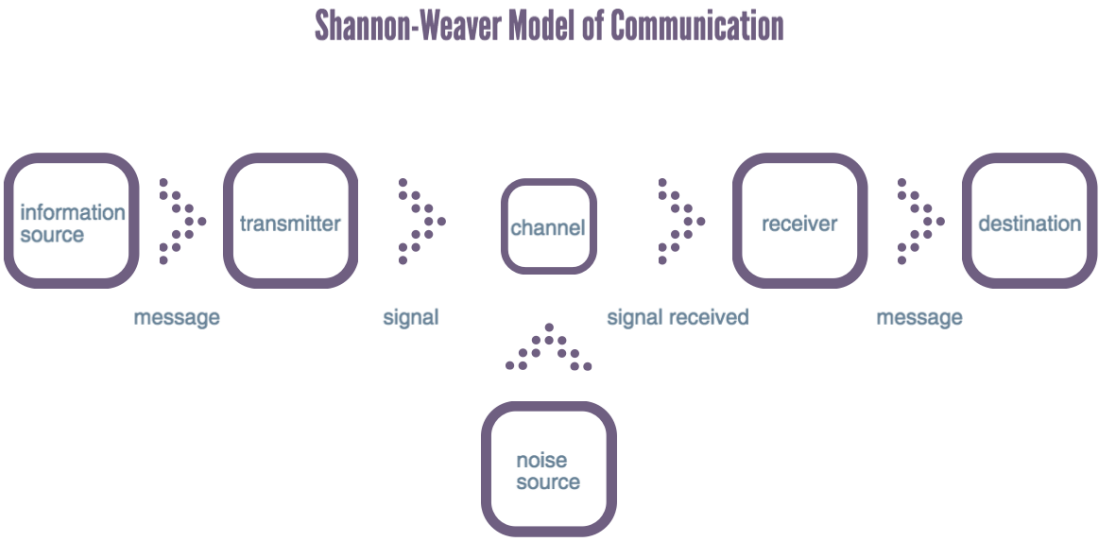

Figure 2.6 Shannon-Weaver Model of Communication. Adapted from Shannon and Weaver (1963)

The Shannon-Weaver model of communication (Figure 2.6) is beneficial when developing communication objects and systems for family use, as the communications and interactions can be easily planned per the flow of information shown within the model. The flow of information is only shown one way (asynchronous communication), however it can be adapted so the transmitter and receiver are interchangeable, allowing for two-way communications, where the information can flow both ways (Figure 2.7).

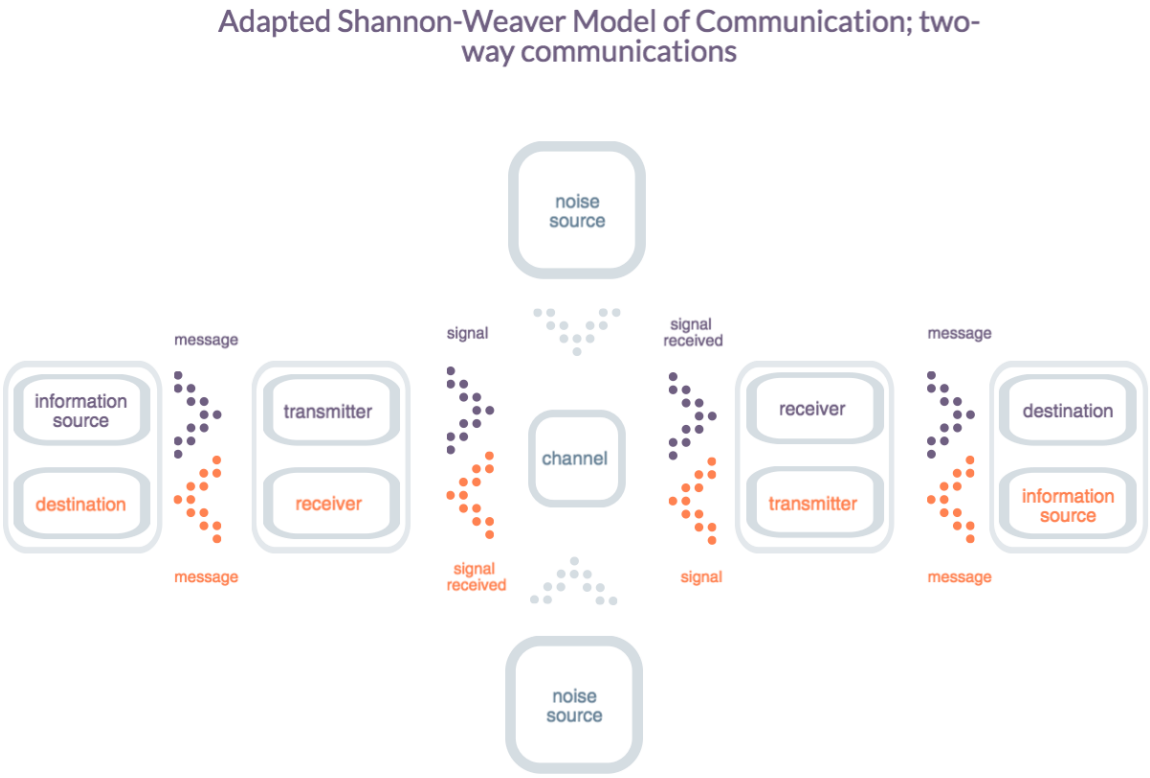

Figure 2.7 Adapted Shannon-Weaver Model of Communication for two-way communications. Adapted from Shannon and Weaver (1963).

Within family communication, 'symbols' are used to create and share meaning (Galvin *et al*. 2015, Davis *et al*. 2007). These unique verbal and non-verbal symbols (facial expressions, body language, gestures, eye contact), can relate to emotions, objects and ideas specific to a family. This shared understanding of meaning within families allows for better family

cohesion (Galvin *et al*. 2015). Verbal and non-verbal symbols are generally shared in close contact (in the same room, space), and not remotely, as meanings could get lost or confused, resulting in possible conflict.

As is shown from historical communication(s) (cave paintings, smoke signals), we do not always need words to communicate (Mehrabian, 2008). However, "*non-verbal communication* [such as symbols and semiotics] *is very limited*" and is usually used to communicate feelings, likings and emotion which can be difficult to communicate verbally (Mehrabian, 2008, p195). With communication technologies predominantly focussed on text based (email, text message, instant messenger), audio (telephone calls), and only occasionally including visual elements (Skype, Facetime, picture messages, emojis) does it becomes difficult to communicate emotions from a distance, that are normally communicated through non-verbal modes of communication such as *visual signs* (paintings, drawings, signs and symbols), and *physical signs* (e.g. body language, facial expression, touching, spatial distance, tone of voice) (Mehrabian, 2008).

Signs or Semiotics (the study of signs) come in several different forms; *visual signs* (street signs, star signs, paintings, drawings), *audio signs* (spoken words, sounds, music), *physical signs* (body language, facial expression, touching), and *written or text-based signs* (written and typed words) (Chandler, 2007). 21st Century communication technologies offer families audio, written or text-based signs as well as visual signs, however they have yet to master physical signs.

The lack of physical signs, in recent communication channels, such as social media, has led to growing concerns over these types of communications. Users of these communication channels are developing more depression, feelings of isolation and loneliness than before (Mclaughlin *et al*. 2010 and Turunen *et al*. 2017). These issues could be attributed to the lack of non-verbal communication available when using these communication channels, resulting in users not having access to the feelings and emotion needed to sustain relationships and wellbeing (Allan, 2017). The 21st Century's connected, yet disconnected world is seeing people share information to hundreds of people at once and the value is placed on how many likes, shares or comments are received. Because this type of

communication offers virtual responses, that are predominantly text based with occasionally visuals (pictorial semiotics), such as emojis, memes, non-verbal cues are limited, leaving a lack of emotion or feeling communicated. 'Likes', 'shares' and 'comments' on social media seem to lack emotional attachment, as people who predominantly use online communications such as social media, and have little or no physical contact or communication become, lonely, isolated and can develop symptoms of depression and anxiety (Mclaughlin *et al*. 2010, Burgoon *et al*. 2016, Turunen *et al*. 2017 and Allan, 2017). This can be attributed to 'feeling ignored' if no one responds to a post (or fewer people than normal respond), 'feeling misunderstood' if the responses are not favourable or in line with the original thinking, or feeling sad or angry even if responses are harsh or unfair (e.g. from Internet trolls) (O'Keeffe and Clarke-Pearson, 2011).

However, positive feelings such as pride and happiness can come from posts such as sharing pictures of a wedding, a birth announcement, a birthday party. Nevertheless, these posts could turn into a negative for the 'poster', if they do not get the desired level of interaction they were seeking (i.e. not enough likes, shares, and comments). Thus, communications through social media can either have a positive or negative impact on mood and wellbeing depending on the positive or negative responses that are received (Valkenburg, Peter, and Schouten, 2006).

Pictorial semiotics are successful when communicating emotions and meanings, where verbal cues are not present or possible (Gamble and Gamble, 2016 and Lucas, 2016). Pictorial semiotics have been used throughout history for instance in cave paintings and hieroglyphics, and are becoming increasingly popular, as emojis, in digital communications such as email, social media and message services (Danesi, 2016). They help give clarity and meaning to communications, when nonverbal cues such as facial expressions or tone of voice are not possible. Thus, as families continue to scatter and technology advances, so too will pictorial symbols in digital communications (Alshenqeeti, 2016).

Social media interactions, while valuable for connecting remote family, friends, and colleagues, struggle to meet the 'knowing', 'loving', and 'caring' values needed to support close intimate communications, due to the openness of the media; meaning all 'friends' or

'anyone' can see posts and comment on them (depending on chosen security settings), and posts can be missed due to the vast amount of information that is shared and appears on newsfeeds every day. As discussed previously, social media can support adult or adolescent remote communications but does not have the ability to support younger children's communications (age two to nine years old) due to its complex nature.

However, research is becoming more common place within HCI that explores interactions and communications through other online technologies such as video chat (Skype and Facetime) (Neustaedter, Venolia and Judge, 2013). This is discussed more in Section 2.5.1 *HCI*, and developed further to look at communication systems specially designed within the areas of smart textiles and wearable technologies (see Section 2.5.2)

Therefore, as technology becomes more dominant in our everyday lives, it is important to not only embrace it but also to question its purpose and push the boundaries of what it can be capable of and how it can help us to communicate in a way that fits and suits our communication needs (Agamanolis, 2009, Galvin *et al*. 2015, Davis *et al*. 2007). Thus, interactions should provide remote awareness of family members, while being simple and enjoyable to use (Hutchinson *et al*. 2003). That is especially the case because communication skills and social cues are learned from birth (Galvin *et al*. 2015, Floyd and Morman 2013) from our families and primary care givers, which allow us to manage our relationships as we grow and develop (Floyd and Morman 2013). Stimulating this learning through, simple fun interactions could preserve relationship bonds of the 21st Century blended family.

2.4 Sociology of Family Relationships

As previously stated, the sociology of what is family is changing. Traditionally a family was a group of people tied together by blood (genetics) or marriage/legal ties (adoption) (Bronfenbrenner, 1986, Dermott, and Seymour, 2011). Thus, it should be recognised that as 21st Century families blend, grow, fracture, amalgamate and scatter, demographic and other social issues must be considered (Ruspini, 2016, Strong and Cohen, 2013), such as:

1. *Age*

2. *Gender*
3. *Size of Family*
4. *Family Dynamics*
5. *Education Levels*
6. *Social Class*
7. *Ethnicity*
8. *Religious Beliefs*
9. *Gender Roles*

Strong and Cohen (2013), suggest eight stages of family life as detailed in Figure 2.8. Each stage brings its own challenges in terms of communication and mediated intimacy. The ultimate objective for a family, throughout each stage, is to ensure strong family relationships and ties to one another.

The two stages that this research focusses on will be stage 3. Families with pre-school children, and 4. Families with school children. Families change and evolve to new circumstances over time, whether these changes are positive or negative. These changes historically (before the 21st Century family), took place in stages 6: 'Family as a launching centre' (when children moved out or 'flew the nest' to attend college, university or to start work and begin a family of their own), 7: 'Family in middle years' (when the children have established their own families and perhaps move from the family's city), and 8: 'Aging family' (when the parents of the grown children begin to become less self-sufficient, perhaps needing extra care due to ill health (mental or physical) and move from the family home into their grown-up child's home, a nursing home or assisted living).

Due to the shift into 21st Century families, changes in living arrangements could happen earlier, and frequently within the third and fourth stage of family life. This forces us to look for new methods of communication to fulfil a family's key aim; protecting relationships.

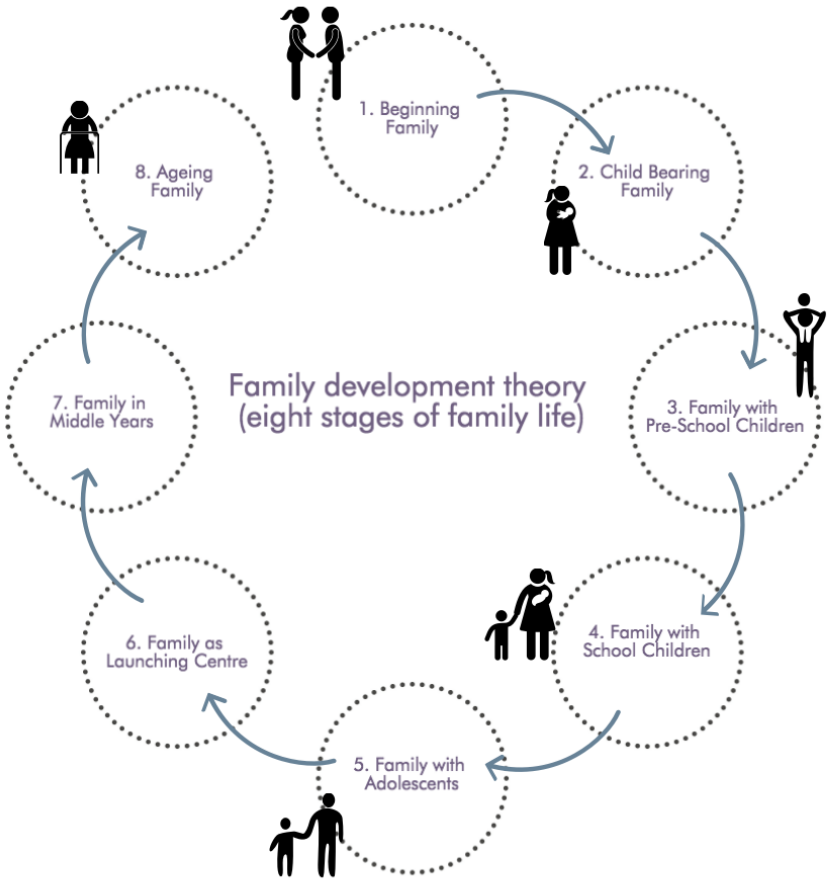

Figure 2.8 The eight-stage family life cycle; adapted from Strong and Cohen's family development theory (2013 p 51)

Fitch (2007), categorises families into two distinct groupings which offers a framework to understand and organise information about families. These categories are:

1. ***Displaying Families*** - which outlines the demographic information of the family.

2. ***Doing Families*** - which as the name suggests encompasses all the practical tasks and activities the families perform (Dermott and Seymour, 2011).

To understand a family's needs, wants and desires from remote communication, all members of the family need to be consulted. This is due to varying viewpoints and understandings of certain situations and communications. Experiences are viewed differently, so just because a family shares the same 'home', does not mean their views of family life are the same or family communication are the same (Jamieson, 2005). It makes sense to theorise, then, that each family member would need a different communication object, offering alternate levels of communication to achieve the desired level of understanding, intimacy, and connection for bonding.

Children were a large part of this research, so it is important to define who the 'children' are. The children who took part in this research ranged from three to twelve years old. Even though both ends of the spectrum are classed as 'children', they have very different communication needs, understanding of communication, and connections to their families when they are apart.

Children at the age of two (24 months) will start to comprehend how to navigate screen-based and other technologies found within the home environment, through curiosity and play (Revelle and Strommen, 1990). By age seven children have a good grasp on language skills and now have the ability to read, type, and spell (Solomon, 1993), by nine they are competent with a mobile phone, and by age eleven have generally had regular access to a mobile phone or have their own mobile device, which many have been used to successfully communicate with family and friends as well as successfully navigate the Internet and social media, for a couple of years (Project Tomorrow, 2008). However, no matter the age or stage of the child one thing remains clear; children have very different "*needs, abilities and interests*" from those of adults (parents, teachers, extended family) (Druin, 2009, pxviii), and therefore need very different media and modes of communication to reflect these differences.

Family members not only influence each other's behaviours when they are together, but their interactions also have a lasting effect when they are apart (Kuczynski, 2003). This theory is called Fit and Co-evolution (Kuczynski, 2003). 'Structural coupling' is a sub theory of Fit and Co-evolution, and was developed by Maturana and Dell (Maturana, 1978 and

Dell, 1985). When parent and child interact daily they will "*automatically co-evolve a close pattern of interaction*" (Kuczynski, 2003, p6). The way a child's temperament is managed (and complemented) by their parents, influences their mood, wellbeing, and personality as they grow and develop (Lerner and Lerner, 1986, Bates, 1989, and Bird, Reese, and Tripp, 2006). Long periods of separation will start to dissolve 'structural coupling', therefore, when parents cannot be present with their child regularly, new solutions need to be sought to manage and monitor their behaviour while simultaneously achieving intimacy.

2.4.1 Intimacy

'Social touch', 'play' and 'laughter' are essential practices both for families who live apart, and those who live together (Neustaedter, Harrison and Sellen, 2013, and Druin, 2009). These practices contribute to be a key theme and are a major factor for building and maintaining successful relationships (Davis *et al*. 2007). For families living apart, or who might be separated (by any amount of time and/or space), technology will play a central role in family bonding, offering an array of new possibilities and choice of platforms for communication.

The word intimacy has different meanings to different people as well as in different disciplines. It is often used to describe sexual relationships (Dermott and Seymour, 2011), however, intimacy, within the context of this research, draws on Jamieson's interpretation of the word describing a "*special bond*" or a "*closeness*" to another person (2005, p2411).

Indeed, Battarbee *et al*. (2002, p237) describe intimacy as a "*sense of closeness*", with these feelings of 'closeness' being as much rooted in the mind as they are in the body. Intimacy is expressed through "*face-to-face conversation*", "*non-verbal communication*" (see Section 2.4.2), and through "*close physical proximity or touch*" (Battarbee *et al*. 2002, p238). Thus, intimacy is not exclusive to adults in sexual relationships; intimacy is a feeling of connection that bonds two or more people through friendship, kinship, marriage, and birth. Furthermore, Blieszner, and de Vries (2001) have defined several different types of intimacy:

1. ***Commitment*** - feeling of cohesion and connection.
2. ***Affective intimacy*** - a deep sense of caring, compassion, and positive regard and the opportunities to express the same.
3. ***Cognitive intimacy*** - thinking about and awareness of another, sharing values and goals.
4. ***Physical intimacy*** - sharing physical encounters ranging from proximity to sexuality.
5. ***Mutuality*** - a process of exchange or interdependence.

Intimacy, then, is not just physical; it is rooted in emotion (how we feel), and can be expressed through action, (what we do for one another). It is built on a two-way exchange of emotion and action. In adult relationships, this exchange is generally equal; in parent-child relationships the parents will have more responsibility over action (caring for their children and making sure their basic needs are met). However, the emotions from parent and child are usually balanced. Thus, intimacy in this research is used to describe the unique bond held between parent and child, through the physical actions of both such as hugging, kissing, playing, as well as parental actions such as making meals, bathing, reading stories, and through emotion i.e., feelings of love, thinking of one another and sharing their feelings (vocally through statements e.g. I love you, or physically e.g. hugging).

If intimacy is a balance between physical actions and emotional feelings, it becomes difficult for families to remain intimate when physical contact is limited or non-existent for prolonged periods of time. A possible solution to this is mediated intimacy. Mediated intimacy, is when people use technologies to 'express', 'share', or 'communicate' intimate feelings with one another (Baterbee *et al*. 2002 and Davis *et al*. 2007), allowing people to be 'co-present' with one another (Baldassar, 2008). Usually these technologies offer different functionality than those for work related use (Davis *et al*. 2007) as they are more "*expressive*" and "*experimental*" (Baterbee *et al*. p 239), allowing them to become intimate communication objects or communicators. Examples of commercially available products that produce mediated intimacy are CuitCircuit's Hug Shirt (CuitCircuit, 2017), Joanna Montgomery's

Pillow Talk (Little Riot, 2017), and Alexandra Deschamps-Sonsino's Good-night Lamp, (The Good-night Lamp, 2017). However, these examples are based on adult relationships and not parent–child relationships. There are some examples of academic research for parent – child mediated intimacy such as Huggy Pajama's (Teh, *et al*. 2008 and Cheok, 2010) and Family Circles (Schatorjé, and Markopoulos, 2013), but these are not commercially available. In fact, currently, Toymail's (2012) products, Mailmen (2012) and Talkies (2017) are the only commercially available products on the market (seven years after this research began in 2010) for parent-child mediated intimacy.

Mailmen (2012) and Talkies (2016) allow families to emotionally connect through their communication systems by giving them communication objects that the families easily understand and can fit in with their daily lives (a toy for the child and an app for the parent). Giving families objects that are easily understood, used and adopted within family life is essential as per Teh *et al*. (2008), Cheok (2010), and Schatorjé, and Markopoulos (2013), when creating emotional connectivity between families through mediated intimacy. Feelings of "*empathy*", "*caring and compassion*" and "*fulfilling* [one another's] *needs*" should be educed through the communication the technology offers (Baterbee *et al*. 2002, p 239).

Toymail offers this through their two-way communication system for family use. Toymail's products enable both parties (parent and child) to send audio messages to and from their communication objects (toy and app). Toymail (2012) use physical objects (Mailmen, small plastic 'mailboxes' and Talkies, plush toys), for the children connected to an app on the parent's phone to record, send and store these interactions.

Thus, research is beginning to show that within family communication systems parents and children need different communication objects, as offering both parent and child the same object for communication does not offer them the correct level of emotional information to feel intimately connected and co-present in family life (Baldassar, 2008, Druin, 2009 and Neustaedter Harrison and Sellen, 2013). Emotional connectivity through technology is using mediated intimacy to allow intimacy to be created through the technology the families use. With Toymail's (2012) products (Mailmen and Talkies) this is achieved through play.

2.4.2 Play

It is said that some of the best interactions within family life come from the quiet moments, where parents and children play together, for example, making an art project, constructing complex Lego builds, playing sports, preparing a meal, or being "*fully immersed in child-centred play*" (Ginsburg, 2007, p186). These periods of 'down time' in 21st Century family life where families are free to play, safeguard relationships, strengthen family bonds and are key to the development of well-adjusted children (Ginsburg, 2007).

Thus, secure family relationships are built through care and play activities. Where separation occurs, it becomes difficult, if not impossible for parents to stay involved in the care and play of their children on a day-to-day basis (Kelly and Lamb, 2000 and Dalsgaard *et al*. 2006, Trevarthen *et al*. 2016). Children learn and communicate through play (Caplan and Caplan, 1973, Burriss and Tsao, 2002 and Ginsburg, 2007), learning certain communication skills such as turn taking (Trevarthen, 2015). Thus, play should be a central concern when designing family communication systems (Toymail, 2012).

A large part of a child's early life is based on and around play (Davis *et al*. 2007, Ginsburg, 2007, Frost, Wortham, and Reifel, 2001, and Burriss and Tsao, 2002). Children retreat into their lands of imagination and fantasy to learn and make sense of the world and their experiences (Ginsburg, 2007, Frost, Wortham, and Reifel, 2001, and Burriss and Tsao, 2002, Trevarthen *et al*. 2016).

> *"The role of play activities to support a child's social and cognitive development is widely recognized by the psychological and pedagogical sciences."*
>
> (Besio, 2004, p120)

Play helps children practice life skills they will need for survival in adult life, such as practical, social, language, and emotional skills (Ginsburg, 2007). Not only does play offer children a controlled environment where they make the decisions, and effect outcomes (Caplan and Caplan, 1973), it also provides them a way to manage their anxieties of abandonment by their parents and care givers (Hughes, 1999). These anxieties can occur,

from a very early age, when children realise that they are dependent on other people to meet their basic needs (Burriss and Tsao, 2002).

> *"Limited activity in pretend play can lead to restricted participation in life situations, which can have social, emotional and cognitive consequences."*
>
> (Stagnitti and Unsworth, 2000, p121)

Play for children is how they learn, grow and develop (Burriss and Tsao, 2002); however, play is also a fun experience for the child, and through play children are bonded to their parents, siblings, peers, and family (Burriss and Tsao, 2002, Ginsburg, 2007). Play "*encourages inter-personal relations, stimulates creativity, adds to the joy of living, and advances learning*" (Burriss and Tsao, 2002, p233 and Caplan and Caplan, 1973). Thesis work such as Yarosh's (2012) Share Table, allows children to continue to share games, homework and stories through Skype videocalls and identical tables placed in each home. Other examples of playful communications are Resolve Design's (2017) project MeMe, allowing people to stay connected using customisable 'dolls' which have varying facial expressions to convey moods and feelings, and Chowdry's (2007) thesis work, Intimate Controllers "*a platform where video games are played by couples touching each other*" (Chowdry, 2007). These bring playfulness (MeMe) and gameplay (Intimate Controllers) into adult relationships, again there is a gap in technology mediated playful communication systems for children.

The process of play and playing is the key to learning and growth, not the result or outcome of the game (Bruner *et al*. 1976 as cited in Besio, 2004). Therefore, it can be assumed that the same is true of play and communication, the act of communicating (for the child, playing with the toy), offers the key to connection and feelings of intimacy for the child. It is through the act of playing that the child will feel connected, and not through the message itself. Through play, Reynolds (1976) states that children construct knowledge by combining their ideas, impressions, and intuitions with experiences and opinions (Hewes, 2006). Because play is exploratory in nature (Sutton-Smith 1967, Robinson 1977), it is a worthwhile tool for discovery and information gathering when working with families, in research, where the

outputs (communication objects and systems) are not defined at the start of the research. Play can also be based on both fantasy and reality; this allows for a true 'dreaming' or blue sky thinking phase within the research due to play's ability to transcend reality (Stagnitti and Unsworth, 2000).

Play can be categorised into two main themes (Casby 1992, Lewis *et al*. 1992):

1. ***Pretend Play*** - a child taking an object and mimicking reality, i.e. a pot and spoon and pretending to cook.

2. ***Symbolic Play*** - a child taking an object and pretending it is something else, i.e. a mop and pretending it is a horse and riding it.

Both pretend and symbolic play can be beneficial in learning about families' communication habits and needs. Observing families acting out communication scenarios with real communication objects (pretend play) and objects not associated with communication (symbolic play). However, it is symbolic play that offers the most interest due to the types of communication objects and systems that were to be designed, within this study. It was assumed that due to the co-design nature of the research focussing on the families' direct needs for communication, the objects produced would not look like traditional communication objects such as mobile phones, computers, and other tablets or hand-held devices. These types of communicators are screen based, offering predominately text and verbal based communications, and are not seen as viable communicators for young children to use (Druin, 2009). Therefore, symbolic play offers scope to transform one object into another or give objects new meaning or purpose (e.g. using a shoe as a phone).

Children develop social awareness and empathy through pretend play where they can act out real-life situations, take on other personas, and step out of their minds and selves (Vygotsky, 1976, Rubin *et al*. 1983, Baron-Cohen, *et al*. 1996 and Trevarthen, Gratier and Osborne, 2014). Pretend play supports all areas of child development such as, healthy development of emotions, convergent and divergent thought, language literacy, impulse

control, perspective taking, and socialisation (Westby, 1991). Indeed, paediatricians are being urged to promote play, especially free play (for example building with blocks, imagination play with toys, physical game play and outdoor play), as a "*healthy and essential part of childhood*" (Ginsburg, 2007, p187). Parents are being urged to limit *passive entertainment* (screen-based activities), such as television, computer games and tablets in favour of more physical play (for healthy bodies) and object or construction play (for curious minds). This will allow children to use their imaginations through play, developing skills such as problem solving, empathy, turn taking, co-operation and other social skills that cannot be learned from solitary gaming or viewing on screen-based devices (Ginsburg, 2007).

Coming from Piaget's (1962) and Vygotsky (1976) theories on play, Lillard (2015 p428 - p433), outlines several different forms of play in childhood:

1. ***Exploratory Play***
2. ***Object Play***
3. ***Construction Play***
4. ***Physical Play*** - sensorimotor play, rough-and-tumble play
5. ***Dramatic Play*** - solitary pretence
6. ***Socio-Dramatic Play*** - pretence with peers, also called pretend play, fantasy play, make-believe, or symbolic play
7. ***Games with Rules*** - fixed, predetermined rules
8. ***Games with Invented Rules*** - rules that are modifiable by the players

Number three on the list, *construction play*, offers research possibilities, within a Participatory Action Research Methodology. Children who engage frequently in construction play have been shown to have greater capabilities in solving problems (Lillard, 2014). This aligns with Csiksentmihalyi (1990), idea of 'thinking through making', where problems are explored, understood and resolved through physical making (prototyping). Furthermore, according to Wilson (1999) and Goldin-Meadow and Wagner (2005) there is substantial findings that working with one's hands contributes fundamentally to learning.

Thus, construction play can be used as a tool for knowledge generation and data collection with the families through workshop settings. Construction play happens between the ages of 3-8 years old and in this stage, children start to build with commercial toys (Lego, blocks), recycled materials (cardboard boxes, plastic bottles) as well as modelling materials (Playdough, clay) (Hewes, 2006). These play activities can happen in solitary play or in groups (Hewes, 2006); group play along with the exploration of materials and ideas will be explored through methods such as workshops, probes, and generative toolkits.

2.5 Technology Mediated Communication

Research into the effects communication technology has on family life is still in its infancy (Aponte, 2009, and Blinn-Pike, 2009); however, communication technologies are and will continue to be useful tools for remote interaction (Allan, 2017). What these communication technologies will look like, and the type of communications they will allow is evolving, and continues to change and grow as we become more aware of the effects separation from our families has on our basic health and wellbeing (Mclaughlin *et al*. 2010, Burgoon *et al*. 2016 and Turunen *et al*. 2017, Allan, 2017).

In the limited studies conducted since 2000, mobile phones seem to have the highest level of family engagement, with texting and voice calls being the preferred way for parents to communicate with their children (Devitt and Roker, 2009). However, reports show that these are adolescent children, aged nine and above, and very little research is being focussed on younger children aged five and under (Ólafsson, Livingstone and Haddon, 2014). By the age of nine, children (generally) have well-established communication skills and strong relationships with their parents. They also have access to Internet ready devices such as tablets, home computers, and smart phones with knowledge of and accounts for many social media and messaging services, such as Facebook, Twitter, Instagram, WhatsApp, Snapchat (Livingstone, Haddon, Görzig, and Ólafsson, 2010 and Ólafsson, Livingstone and Haddon, 2014), which they use daily to communicate with family and friends. However little evidence can be found for younger children and how they communicate throughout the day with their parents when apart (Plowman and Stephen, 2003). It is assumed that this always takes place through a third party: childcare provider, grandparent, school, nursery.

It is essential new technologies are understood by children and that they support children's communication needs in the correct manner (Druin, 2002).

Children's use of technologies such as the Internet, smart phones, tablets, and television starts at a very early age (Ólafsson, Livingstone and Haddon, 2014). A review of children's use of online technologies in Europe shows that (Ólafsson, Livingstone and Haddon, 2014, p25):

- Children's media use begins at a very early age. A majority of 0-2 year olds listened to books, radio, and sound recordings.

- One-year olds watch TV and visual recordings daily and they mainly use media in the company of their parents or other adults.

- At the age of 3-4, a child's individual taste in media begins to develop, and the tastes of girls and boys begin to diverge.

- The greatest difference between 7-8 year olds and younger age groups is the dramatic rise in the use of digital games, the Internet and mobile phones.

- The most useful forms of collecting data turned out to be observation at home (0-3 year olds), and interviews (over 4 year olds), including questionnaire surveys conducted by peers.

- Answering an adult researcher's questions seemed to be easiest for a child when they were allowed to engage in some meaningful activity e.g. drawing or playing during the interview.

Using physical activities, such as generative toolkits and prototyping, will be suitable tools in connecting with children whilst allowing them to think through their making and giving them the confidence to verbalise their thoughts and feelings surrounding their communication needs.

Using a regular two-way communication medium is essential to feel connected (Yarosh, 2012), if the communications are only one way, the sender receives no feedback, and therefore does not know if the information has been received and how it has been received, or if the recipient understands the meaning of the information and how they feel about the information being shared. Communications such as email and mobile devices (text messages, phone calls, social media) are used several times a day because of their convenience and ease of use. Thus, they can be used as intimate mediated technology in adult relationships (Druin, 2009). However, they do not work for children due to the accessibility and usability of these communications. Adults also often use hidden meaning within words such as sarcasm, tone (Hutchison, 2010). A child needs facial expression, tone of voice, and often physical contact to understand the meaning that another person is communicating (Battarbee *et al*. 2002 Blieszner, and de Vries, 2001 and Hutchison, 2010). This combined with limited language and reading skills of pre-school children make some 'adult' communicators (email, text message, instant messenger), impossible for them to use successfully (Yarosh, 2012).

Connection comes from the flow of information to and from a person (Neustaedter, Harrison and Sellen, 2013), albeit this is argued within the context of the workplace for task management and negotiation. However, the basic principles of communication still apply. Email, phone calls, social networks, and Skype calls are the perfect solution for work and, in the most part, adult communications and relationships (Neustaedter Harrison and Sellen, 2013, and Yarosh *et al*. 2009). Yet, the use of these same communication technologies in a family environment, that includes young children, lacks intimacy and connection (Neustaedter Harrison and Sellen, 2013). Emotion and intimacy are paramount for building and sustaining healthy intimate relationships but are not generally required in a work/business environment. Within family communication it is not the context of the message that is the important for connection, it is the feeling of connection and the reassurance and understanding that loved ones are virtually co-present, while not physically there; connected when not together (Neustaedter, Harrison and Sellen, 2013).

Technology does, and will continue to facilitate communications, but it is unclear how emotional connections, love and intimacy, will be enabled in families, if it is predominantly done through objects and not in person.

Papert (1996) is concerned about children's 'easy adoption of technology' and how this can make them increasingly more independent from their parents at an earlier age. Children have the capabilities to find out the information they seek, efficiently from a machine, rather than having to wait for a convenient time and a willing adult to share experience and knowledge with them. However, this vast world of knowledge and learning, or indeed recreational activity (watching shows, playing games online) should not replace physical contact, communications, and interactions (Allan, 2017). This has been shown to be detrimental to physical communication, and in turn mental health (Ainsworth, 1982, Aponte, 2009 and Bates and Bayles, 1988).

There are numerous studies outlining the detrimental effects online communication and technology can have on families and individuals in terms of their relationships and mental health and wellbeing, but there are few showing the positive effects (share schedules, updates on daily goings on) that technology can bring to relationships (Bacigalupe *et al*. 2014, Allan, 2017).

Research into ICT and the impact it has on family life and communication within the family are limited and inconclusive (Carvhalo, 2015). Many studies have focussed on a single technology (mobile phone, email, Skype), or one situation (conflict, cohesion) but they do not offer a cohesive list of what types of technologies are useful for family use (Carvhalo, 2015). However, research surrounding ICT use within families is rapidly expanding (Carvhalo, 2015), with Bacigalupe, (2011), Hertlein, (2012), Gora, (2009) and Watt and White (1999) predicting this type of communication will be a vital mode of communication in the future of family communication. Yet, compromises in the design of family communication systems, must be made concerning awareness and privacy (Tee, Brush, and Inkpen, 2009). This is a major concern within family communication research, as children's safety is of the upmost importance.

Technology mediated communication comes in two main forms:

- ***Marketable Products*** **-** such as mobile phones, tablets, internet ready televisions, desktop and laptop computers which predominantly offer audio and visual communications.

- ***Conceptual Products*** **-** with research endeavours, such as Blossom (Wallace, 2007), Hamefarer's Kist (White, 2008), and Share Table (Yarosh, 2012), which can offer audio, visual and tactile communications.

Conceptual products can offer families a deeper sense of emotional attachment through the wonder and delight of the artefacts (Wallace, 2014). These projects foreground the family members' connections to one another, focussing on the emotional connections over the marketability and mass production values for commercial products. Much can be learned about family communication from the methods (mainly participation focussed) used within these types of research. This will help other researchers work with families through a cooperative design process, offering solutions, suggestions for communication objects and systems, along with a list of desired modes of communications and possible objects for use within family communication (Chapter 6, Section 6.2). However, it is important to note that the adoption of family communication systems is voluntary (unlike mandatory communication technologies deployed in the workplace). Therefore, the family communication systems must be attractive to families and offer them easy to use and convenient communications, or they will not be used (Judge, and Neustaedter, 2014).

Choosing a participant focussed methodology that allows for complete family collaboration within each stage of the design process should help the systems be accepted within the family home (see Section 2.8 Participatory Action Research).

In the following sections, contextual research in Human Computer Interaction (*HCI*), Section 2.5.1, and *Smart Textiles and Wearable Technologies*, Section 2.5.2, will be explored further. Participatory and collaborative design processes, methods, and technologies were taken from each of the afore mentioned areas and helped form the methodology (Section

2.8, *Participatory Action Research*).

2.5.1 HCI

Over the past fifteen years, children have been included in the design of new technologies, this has mainly been through Human Computer Interaction (HCI) but it is possible for them to have a voice throughout the whole design process (Guha, Druin, and Fails, 2013). Participatory design is one of the main methods for working with children within HCI and participatory design principles can be translated into textile design for inclusive methods of designing for and with families.

The following research, that explores interactions and communications through online technologies such as video chat (Skype and Facetime), can be found positioned in Figure 2.2, showing its modes of communication (one or two-way, soft or hard communications), and more information about each research project can be found in Appendix 2. This type of family focussed research is becoming prevalent in HCI (Neustaedter, Venolia and Judge, 2013). The studies of: Neustaedter, Brush, and McDonald (2008), Ames *et al*. (2010), Judge, and Neustaedter (2010) and Oduor, Neustaedter, Venolia and Judge (2013), show how families can utilise video chat to enhance intimacy and bonding (e.g. grandparents observing their grandchildren play (Ames *et al*. 2010 and Judge, and Neustaedter, 2010)). Other notable systems that were designed to aid in the sharing and partaking of everyday activities are Family Window (Judge, Neustaedter, and Kurtz, 2010), and Family Portals (Judge *et al*. 2011). These systems were always 'switched on' and allowed the separated family to be present in each other's lives (at mealtimes, through play, story time), through the 'windows' or 'portals' (video chat screens in digital frames).

The Share Table (Yarosh, 2012), a space that allows for daily interaction and play through a screen, video chat and two identical tables placed in each residence, Peek-A-Boo (Neustaedter and Judge, 2010), a mobile version much like Family Windows and Family Portals, Story Play (Raffle *et al*. 2010), Story Visit (Raffle *et al*. 2011) both from Nokia (2017) research, which embeds video chat into physical books and online platforms for distance

family interaction at story time, are all other examples of the screen based communication technologies that are being explored to support family communications. These actively encourage both verbal and non-verbal interactions through, play, stories, and everyday activities.

Video Play Date (Yarosh, 2010), IllumiShare (Inkpen, 2012), and Video Kids (Inkpen *et al*. 2012) stem from Microsoft Research which facilitates remote child friendships through video chat. Thus, allowing children to play together whilst in their separate homes. This type of child to child interaction would be especially useful for blended families with step or half siblings who spend their time living in separate residences, or for families separated by illness (where one child needs to spend long periods of time in hospital or quarantined from siblings), as would allow them to continue their play, building their relationship bonds whilst apart.

Common to each of these video chat communication systems is the synchronicity of the communications they all endeavour to emulate. These systems attempt to promote physical communication by using basic communication 'rules', such as 'turn taking' and 'question and response', helping to stimulate a two-way interaction between families (Richardson, 2004 and Lenhart *et al*. 2007).

Thus, there are many examples of HCI research focussing on issues surrounding family communication and separation. Further information on these research projects can be found at the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI) Conference website (https://sigchi.org/). Projects such as the interLiving project (Interliving, 2003) and Living Digital (2017), a Socio-Digital Research Group which supports being human in a Digital Age through the design of technology, are other rich information sources on personal technologies for the 21st Century family.

This section has highlighted the reflective and empathetic approach that is sought in HCI when working with people who may be considered vulnerable or marginalised, enabling researchers to conduct ethical research in sensitive settings (Singh and Jain, 2017). This empathetic and reflective approach to research needs to be explored further within smart-

textiles and wearable technologies. Using the tactility and comfort cloth brings, and the communication possibilities HCI brings, offers exciting opportunities and possibilities for research into connecting the scattered 21st Century family.

2.5.2 Smart Textiles and Wearable Technologies

This exploration examined not just how others in the field had successfully used wearable technologies and smart textiles within communication objects and systems previously, but also how the researcher could adapt these to suit the communication needs of the family participants in the studies.

> "*Textiles help us communicate and learn, add beauty and stimulation to our days, and make our lives richer*"
>
> (Gordon, 2013, p 202)

Textiles are key to human existence, they protect us, stimulate us, comfort us and bring us joy. They have many uses in everyday life, but their importance is often overlooked. Mostly they are seen as necessities for living be that for protection or wellbeing (e.g. clothing, bedding, furnishings), frivolities (e.g. fashion), or comforters (e.g. children's security toys and blankets). Nevertheless, textiles and their value to us, should not be ignored.

From birth we are surrounded by textiles, we are swaddled in them for comfort and warmth, washed with them for health and hygiene and given them for sensory experiences and comfort (e.g. soft toys, blankets, scraps of cloth) (Brett, 2003; Damhorst *et al*. 1999). Relationships with textiles and our understanding of them grow as we do. They are woven into our history, culture, political beliefs and our sense of self. Textiles have been used as group identifiers (e.g. Scottish clans and tartans), for storytelling (e.g. in tapestry) and social identity (e.g. through politics, labour and human rights) (Nevay *et al*. 2017; Barnard, 2002; Mitchell, 2011).

Relationships between people and textiles are examined by Andrews (2008), through material culture and textile semantics. Building on product semantics, which looks to understand the relationship between person and product, the interactions that occur, and the meanings that can be drawn from these (Krippendorf and Butter, 1984), Andrews (2008), outlines the importance of both object creation and object interaction within an objects value and meaning. Thus, objects 'communicate' their value through the material they are made from, as well as their functionality and design. For example, silk is seen as expensive, opulent and feminine, whilst denim is seen as hard wearing, functional and affordable (Andrew, 2008).

Textiles are ubiquitous and familiar to most people within most cultures. However, due to the passive nature of traditional textiles, their capacity for communication is restricted, and often overlooked within 21st Century communication (Park and Jayaraman, 2003).

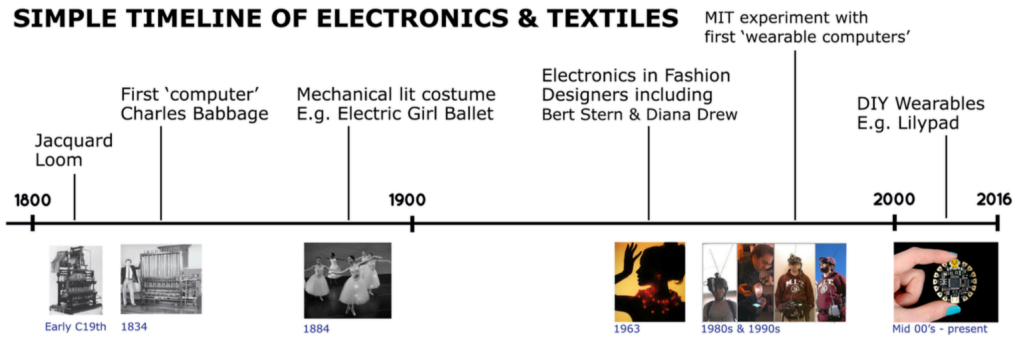

Figure 2.9 Timeline mapping textile development (Nevay *et al.* 2017, informed by Buechley *et. al.* 2013)

However, in recent years a new category of textiles, *smart textiles* or *e-textiles* has been gaining traction (Fairburn, Steed, and Coulter, 2016). These smart or intelligent textiles have the capabilities to '*react and communicate*' with their environment due to their electronic programming (Gordon, 2013, p 205). Smart Textiles are "*engineered with internal sensors that*

react to stimuli from mechanical, thermal, chemical electrical, or magnetic sources" (Gordon, 2013, p205). A simple timeline displaying the evolution of traditional textiles into smart textiles can be found in Figure 2.9.

This reinvention of textiles from 'traditional' to 'smart' affords cloth to monitor health; such as babies' that are vulnerable to Sudden Infant Death Syndrome (through temperature), by wearing the 'sensory baby vest', and soldier's vital signs, by wearing adult 'life vests' (Gordon, 2013). Thus, textiles hold vast opportunity in health monitoring due to their close proximity to the body, being worn on or close to the skin. It is expected that hospital patients in the future will wear smart undergarments to non-invasively highlight trends in vital signs, such as changes in blood pressure, respiratory rate, pulse rate and oxygen saturation (Massaroni, *et al*. 2015). This early intervention can alert medical staff to possible complications through constant monitoring of a patient's vital signs as well as drawing on past patient data, to predict patterns and identify warning signs of patient deterioration (Van Langenhove, 2007). Thus, the capabilities of smart textiles, are extensively explored within health, physical and mental wellbeing, through disciplines such as biomonitoring, rehabilitation, therapy and ergonomics, highlighting their beneficial nature (Malins et. al, 2012; McCann & Bryson, 2015; Paradiso & De Rossi, 2008). These explorations offer evidence which highlight the benefits textiles can offer in health monitoring and as well as psychological fulfilment through the use of sensory textiles and making (McCann & Bryson, 2015; Cotten, 2013).

Due to the ubiquitous nature of textiles, their versatility and acceptance within virtually all cultures, it is proposed, that textiles can have societal benefits not just within the communication and monitoring of patient care but also within personal communications. Smart textiles offer many characteristics that are identified within successful communication (multi-sensory, tactile, visual, and responsive). Thus, smart textiles can be leveraged to engage families, through more intuitive communication systems, strengthening intimacy and family bonding whilst they are apart.

Smart textiles offer scenarios where people can combine the digital with the physical. "*They invite people to reengage with the physical world while honing their technological literacy*" (Buechley *et al*. 2013, p2). However, cost is a main factor when considering mass integration

and adoption of smart textiles and wearable technologies. We already carry with us sophisticated technology, in the form of a smartphone that allows us to navigate physical spaces (through GPS), connect with work colleagues or friends (through email, text messaging and a variety of social media outlets), and take high quality pictures and videos (through the camera). Thus, it makes sense to base wearable technologies and smart textiles around this pre-existing kit. It allows the 'projects' to be affordable thus plausible as the core 'wearable computing' device (smartphone) is already owned by the consumer (Buechley *et al*. 2013, p212).

By using participation methods (co-creation, co-design, participatory design, meta design), it is possible to combine technology with textiles so as to result in family communication systems that are tailored to the individual family's needs, regardless of their separation issues. These considered and empathetic design solutions aim to create higher levels of intimacy, for families with young children (aged two to nine), than current favourite communication technologies (the telephone and Skype). A participatory action research methodology would adapt easily to family situations, providing methods that would successfully elicit the required information, from participant families to develop communication systems organically. The methodology will also allow for the participation of designers and technical experts, through co-design practices resulting in fully working prototypes.

Mottram (2004), Stead (2005) and Lynas (2010) outline research on emotional connections to textiles. This research can be developed further by adding new social dimensions and new ways of interacting and communicating through smart textiles and wearable technologies (e-clothing) (Fairburn, Steed, and Coulter, 2016). This indicates the possibility that soft textile objects could be used within intimate communication systems for families. These wearable or portable (Kettley, Breedon, and Briggs-Goode, 2009) objects can offer intimate connections through the co-design process as well as the materials used.

There are many social wearables available today as the demand for mediating intimacy in relationships increases. However, these are mostly either "*generalized and lack consideration for cultural context and needs of varied user groups*" or are bespoke one-off pieces (Silina, 2016,

p1). Indeed, most of the research found that was successful in mediating intimacy were tailored custom made pieces. Intimacy is instilled in the objects through the methods of making, often co-created or co-designed with the end users. Novel characteristics within communication objects, such as beauty or treasured materials such as porcelain, textiles, and precious metals, were used to make personalised hand-crafted objects that would connect 'family', through the emotion and intimacy they fostered.

Beauty in this context, moves past pure aesthetic of an object to the meaning behind the object, essentially focussing on the objects soul, e.g. what makes the object special, treasured or loved. Wallace and Press (2004) commented that this type of beauty can be used to facilitate engagement within digital enabled objects. The perception of beauty is subjective; thus, objects can be regarded in different ways by different people. Made objects, such as a child's macaroni Christmas tree decoration will hold more value to the child's parents than a store bought one, as these foster intimacies. The value is not monetary, but sentimental. It will remind parents of the early stages of family life as their children grow into adults and move away from the family home. This personal resonance and connection the parents have with this hand-made decoration, transcends the object itself. It is not necessarily the object that is beautiful or important, but the memories and love it represents.

Wallace has shown this purpose and need for beauty, when designing emotional attachments and intimacy within objects. Through her thesis work and with research projects such as Traces (2004), Blossom (2004), and Sometimes (2004). In these projects she made intricate and delicate personalised family artefacts, to connect and reminisce about remote family members.

Wallace's more recent work, Anchor Points (2012), is a system of novel objects anchoring families together when the fathers are out at sea. They were made of handkerchiefs printed with children's drawings, and a cylindrical leather case, housing wooden fishing tools and tokens made by the children, that contained "*radio-esque*" technology (Wallace, 2012, p4). The technology enabled the families to record stories and conversations which could be listened to when the father was at sea or when he returned home. This is a highly personalised and thoughtful asynchronous mode of communication that recorded family

stories to embody intimacy and connection whilst apart. Wallace (2012) used ethnography skills; observation and discussion, with the families to understand their separations, enabling her to design beautiful and thoughtful objects that would ease family separation. Beautiful objects can connect us spiritually through memories and feelings of intimacy. They can also enable us to trust or access technology that embedded within an object, which may not be possible if 'packaged' in a different way. Thus, aesthetic design should not be viewed as a frivolous or last-minute decision. It should be integral to the design, especially when designing personalised objects, for use in intimate family communications (Wallace, Dearden and Fisher, 2007 and Wallace 2014).

'The Emotional Wardrobe' (Stead *et al*. 2004, and Stead, 2005) draws on the beauty of clothing to "*represent[s] and stimulate[s] emotional response[s] through the interface of technology*" (Stead *et al*. 2004, p 282). This was a conscious shift away from the 'wearables' that are being produced by the electronic and technology sectors, amalgamating fashion and technology, to bring about a new paradigm in fashion and textile design, by giving wearables a new "*aesthetic communicative and expressive purpose*" (The Emotional Wardrobe, 2017). Giving the wearer the opportunity to dynamically personalise their clothing, could create attachment to the garments created. This offers valuable possibilities for sustainability and intimacy being created within and through the garment (Stead 2005 and Ballie, 2014).

Another electronic textile project, An Internet of Soft Things research project (IoST) (2016) "*challenges how a radically connected world would be designed to benefit human well-being, and in particular, what types of experience can be instigated from smart textile interfaces*" (An Internet of Soft Things, 2016). The IoST research project utilises the skills and knowledge of their multi-disciplinary research team of interactive textile developers, computer scientists, and psychotherapists, to develop a participatory design methodology and free downloadable workshop worksheets that can be used to create electronic textile samples. The workshops and 'making' exercises are used as a method to allow workshop participants (mental health service users) to reflect on their experiences and feelings through the practical making exercises.

The review of these projects showed that technological functionality (i.e. pushing the physical capabilities of the technology) is shifting and is no longer the focus when developing wearables and smart textiles. The human element of the development of new technologies is taking over as the main concern. Current motivations focus on how we can use the technology (hardware and software) to deliver emotionally intelligent solutions to social issues people face today. The human element is fundamental; therefore, it is not what can be created that matters, it is the ways in which technology can be used to enhance and enrich our lives.

However, the growth of smart textile rests with their economic solvency and their technical challenges. While this was not a main concern of this research, it is important to note that the progression of smart textiles and wearable technologies depends on funding as well as collaborative working to create new solutions or develop and 'hack' existing technologies. Indeed, the main project discussed within this thesis, The Trace Project (Chapter 5) would not have been possible without external funding from New Media Scotland (section 5.3 and appendix 4.1). This allowed for a collaborative team to be built (section 5.3.1), as well as financed the technology needed to develop the Trace Communication System. Thus, for the survival, and graduation of smart textiles from a hobbyist, DIY maker culture, to a serious research agenda, relies on them being able to deliver qualities and possibilities that smartphones cannot. Therefore, research and design work should focus on soft technologies and or technologies that are close to the body or worn on the body. These could include *applications* such as "*heating, cooling, body sensing, environmental monitoring and protection*" (Buechley *et al*. 2013, p212). Indeed, Vetere *et al.* (2005), outlines the possibilities smart textiles can offer in non-verbal, physical interactions, due to the social and haptic (phatic) research and development where textiles are being interwoven with sensors, buttons and switches offering heat, pressure or light capabilities. Furthermore, Fairburn, Steed, and Coulter, (2016), state that smart textiles have new applications and exciting possibilities in communication. Thus, smart textiles should be considered when designing intimate communication systems relevant to family life, as they have opportunity to offer families meaningful communication objects and systems that resonate with 21st Century family life.

2.6 Participatory Action Research

Participatory Action Research is a qualitative research methodology (MacDonald, 2012) often referred to as Action Research (Walker, 1993) or a 'subset' of Action Research (Gillis and Jackson, 2002). In fact, Kindon, Pain, and Kesby, (2008, p1), refer to Participatory Action Research as an umbrella term that covers a variety of approaches to Action (orientated) Research. The term Action Research was coined by Kurt Lewin in 1946, to define a "*spiral action of research aimed at problem solving*" (Walker, 1993, p1), an iterative process of 'interplay' between participant and researcher where activities move between action and reflection (Fisher and Ball, 2003, p209). Action Research includes a variety of terminologies such as 'participatory action research', 'participatory research', 'community-based participatory research', and other forms of 'participative inquiry' (MacDonald, 2012, p35). Through an Action Research methodology, researchers can influence 'social change' (Greenwood and Levin, 1998, Koch and Kralik, 2006 and McNiff and Whitehead, 2006), which is the objective of this type of research (MacDonald, 2012).

O'Brian (1998) describes Action Research, as a process of 'learning by doing'. This results in many iterations and cycles of research, development, and testing taking place before arriving at a final prototype or solution (Figure 2.10).

Participatory Action Research is a form of applied research that has "*real world effect* "and is "*guided by a research topic/question that emerges from the community of interest*" (Walker, 1993, p2). It is "*a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes*" (Reason and Bradbury, 2001, p1).

Essentially Participatory Action Research brings together a group of people affected by the same issues and lets them discuss what lies at the root of the problem, then together form a solution (Kidd and Kral, 2005, Walker, 1993). This approach, when working to solve specific problems, seems '*natural*', '*human*', and '*intrinsically sensible*' (Kidd and Kral, 2005, p187). Participatory Action Research does exactly what it says (Kidd and Kral, 2005, Walker, 1993) 'participation', to take part in something and 'action', instigating change, through research (Merriam-Webster, Incorporated, 2004). It is research '*by*', '*with*', and '*for people affected by a particular problem, which takes places in collaboration with academic researchers*'

(Kindon, Pain and Kesby, 2008, p90). Participatory Action Research then, supports co-development (McIntyre, 2007), through working in a collaborative manner, giving opportunity to change, improve and understand the world (McTaggert, 1999). Co-development, accesses everyone's experiences and knowledge on a given subject, offering a broad view of the issues. Once these issues are agreed, further discussion and research will be completed, allowing for the exact problem and therefore the specific research questions that need answered to address the problem.

Figure 2.10 Action Research Model, Adapted from Reason (2000).

Action Research is a tool that is increasingly used within the development of smart textiles and wearable technologies due to the flexibility of the methods and the user centred and participatory approaches, see works by Fairburn, Steed, and Coulter, (2016), such as *Molecular Imprinted Textiles (MIT – 2009/10), Future Textile Visions (FTV – 2010/11), Design Specks: Connecting People with Speckled Computing (*Arvind *et al*. 2013*), Second Skin (*Steed, and

Fairburn, 2016*), and The S*** Word: Designing the Empathic Underward- robe (2014)* for methods relating to an Action Research methodology. There then is opportunity to shift paradigms of design into a collaborative, transformational and empathic user experience (Steed, and Fairburn, 2016).

However, Christopher Frauenberger (in Sanders, 2017), talks about the differences between Action Research and Participatory Design, he outlines these by stating Action Research focusses on "*changing an existing social situation*", while Participatory Design is directed towards "*designing an artefact*". Participatory design offers less control to researchers as this is passed over to the co-designers. So, having a Participatory Action Research methodology, allows for families to come in at key points of the process (planning, acting, observing and reflecting), being active co-designers, driving the process and outcomes, while leaving some control with the design team to choose the correct technology that will be safe, secure, and robust enough for family use.

Turnbull, Friesen, and Ramirez (1998), use Participatory Action Research in family research, due to its collaborative nature. All family members as well as the research team are involved in the process. However, they have found each collaborator has different jobs to do and has the opportunity to wear different 'hats' depending on the stage of the research. Whilst both the researcher and the families are viewed as co-designers, the researcher is the "*leader*", whilst the families are "*ongoing advisors*" during the research (Turnbull, Friesen, and Ramirez, 1998, p178). Therefore, the process of Participatory Action Research allows the researcher to work with the families through the creation of ideas (interviews, worksheets, workshops), problem solving (workshops, prototyping, user generated content) and reflecting (discussion, interviews, self-reporting), bringing them in at key stages as a co-designer or an advisor to the research.

Whilst the idea that each co-designer (researcher, participant, technologist, designer), is not just a co-designer, but adopts other roles depending on their personal knowledge, experience and skill set, the stance of the researcher as a 'facilitator' (Hogan, 2005 and Ballie, 2014), and not a 'leader' is preferable. The term leader suggests a boss, an overarching presence who holds influence and power over the others, whilst key decisions and plans

need to be made, the term facilitator instead of leader, enables the other co-designers to feel like they can have an opinion and their contributions can and will influence the research.

2.6.1 Collective Creativity Fostering a Participatory Mind-set

Different levels of creativity exist among individuals, therefore, designers must support 'co-designers' (which can include non-designers and designers), in this case families, through the design process. This can be achieved by suggesting appropriate methods or tools to aid creativity (Sanders, 2010). A participatory mind-set (Sanders, 2008), allows 'everyone' (stakeholders, users, designers), to become part of the design process (Figure 2.5). However, as designers and the facilitators of the participatory design process, we must support and provide everyone with appropriate tools to be creative. This participatory mind-set allows for a sense of collective creativity, where both designers and non-designers can work together to provide solutions to the problems they are faced with. There are many terms for this idea of collective creativity, however 'citizen participation' seems to encompass collaborative design methods such as co-design, participatory design, meta design and collaborative design (Ballie, 2014), which all stem from a sense of collective creativity. These terms seem rather muddy and are easily interchangeable; they hold different meaning to different disciplines, by taking an overarching view of collective creativity, and using each method or process when applicable depending on the co-designers (families, technologists, engineers), offers flexibility when working with these different groups of people (designers and non-designers).

Therefore, by actively engaging in a collaborative design process, both designers and non-designers have the capability and opportunity to aid in the development of products and services, through collectively solving issues, which actively prolongs attachment and engagement with the product or service (Niinimaki and Hassi, 2011).

Indeed, through allowing families to personalise the family communication systems and objects, increases the chances that they will be adopted by the families and that the children will feel emotional connections through them (Jones, 2009). Oulasvirta and Blom (2008),

discuss the value of personalisation, and what he factors are that drive us to do it.

Sanders, (collaboratively with Peter Kwok Chan, Pieter Jan Stappers, and André Liem), over the past 10 years has been developing her Map of Design Research (Figure 2.11). This map of human-centered design methods shows the difference in methods between the "*expert mindset*" (top left) and the "*participatory mindset*" (top right) (Sanders, 2008 and Carlson, Peake, and Joiner, 2014). Sanders (2008) map has been edited showing the traditional textile design mindset (1); top left, and how this mindset is shifting from left to right as textile designers start to focus on social research methods and collaborative design practices. The research discussed in this thesis will be situated mostly within the top right hand quadrant, as it is design-led using a participatory mind-set (Figure 2.11), as this is where co-design happens.

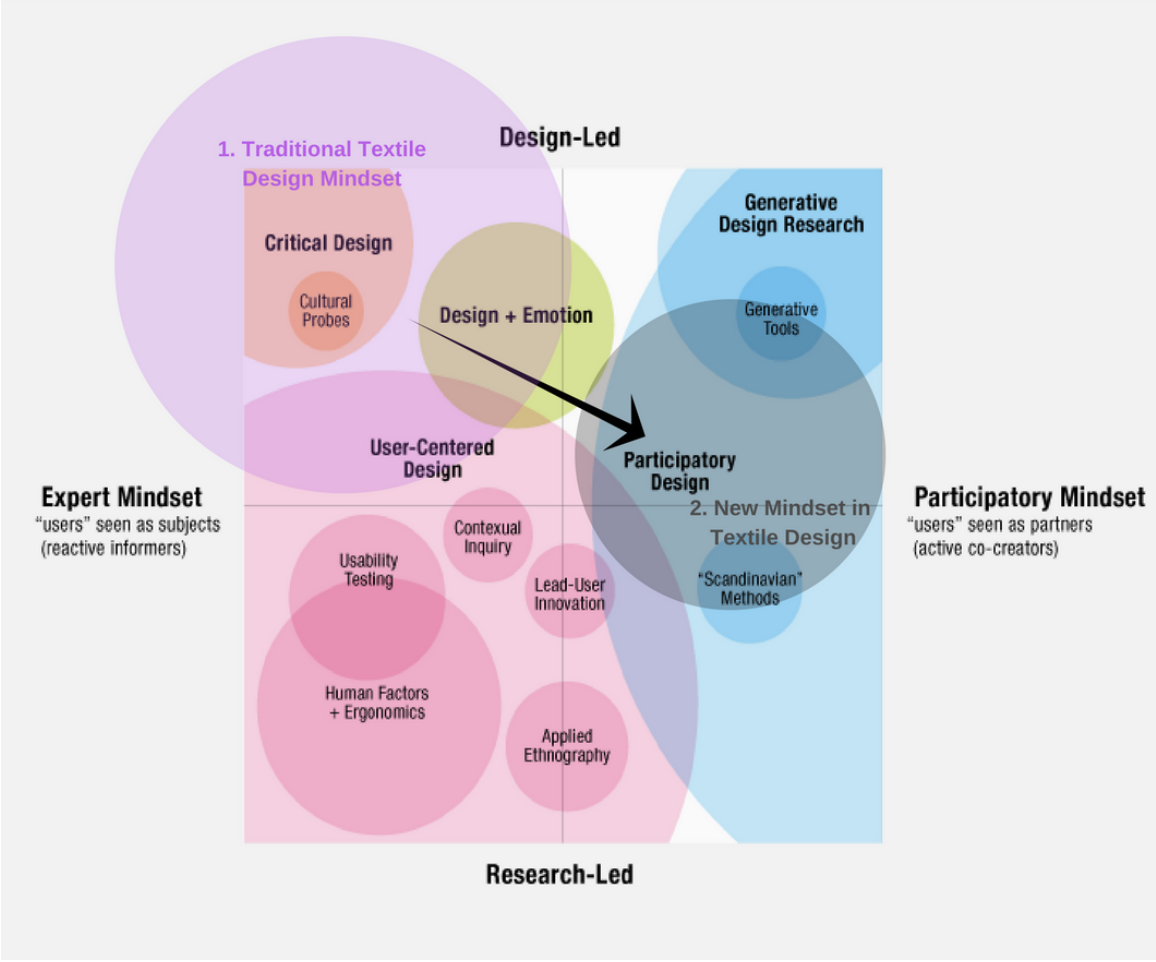

Figure 2.11 Map of Design Research, Sanders (2008), Adapted by McNicoll, 2017

Understanding this design landscape and the results different participatory methods can produce, when applied appropriately within different groups (i.e. designers, non-designers, technologists, engineers), offers the flexibility of method selection. This allows researchers to cross over into other segments, if and when appropriate. Mapping exercises are a useful tool in understanding a problem and aiding in the appropriate approach for the research (Sanders, 2008).

Sanders explains that the "*design and emotion bubble emerged in 1999 with the first Design and Emotion Conference in Delft, the Netherlands*" (http://www.designandemotion.org), and that this area brings together research-led and design-led approaches to design research (Sanders, 2008, p14). The design of an emotion bubble aids in a collaborative process, helping researchers to understand and empathise with their co-designers.

When children and adults work collaboratively, idea elaboration stands out as the most important aim (Druin, 2002 and Guha, Druin, and Fails, 2013). Idea elaboration starts with a single idea from one of the participants (adult or child), which is built upon by the collective group, adding new ideas, until a fully resolved idea is reached. As this process, can be quite daunting for young children (due to confidence levels and language skills), collaborative methods are put in place, such as design toolkits, to aid this process (Guha, Druin, and Fails, 2013).

2.6.1.1. Say, Do, Make

There are many ways we can learn from people about their memories, their current experiences and their ideal experiences. We can listen to their sayings, we can observe and interpret what they say and do to uncover what they know, and we can also move past their sayings and doings and try to understand their relating's and what they feel. In doing this we can start to understand what people dream (Sanders, 2002). See Figure 2.12.

Participatory design is sometimes criticised for focusing too much on what users say (Munford *et al*. 2003). The say, do, make model allowed me to look at what the families say,

but also what they do and how they make. This allowed the families to not just talk about their communication issues, but also act out scenarios and make lo-fi prototypes.

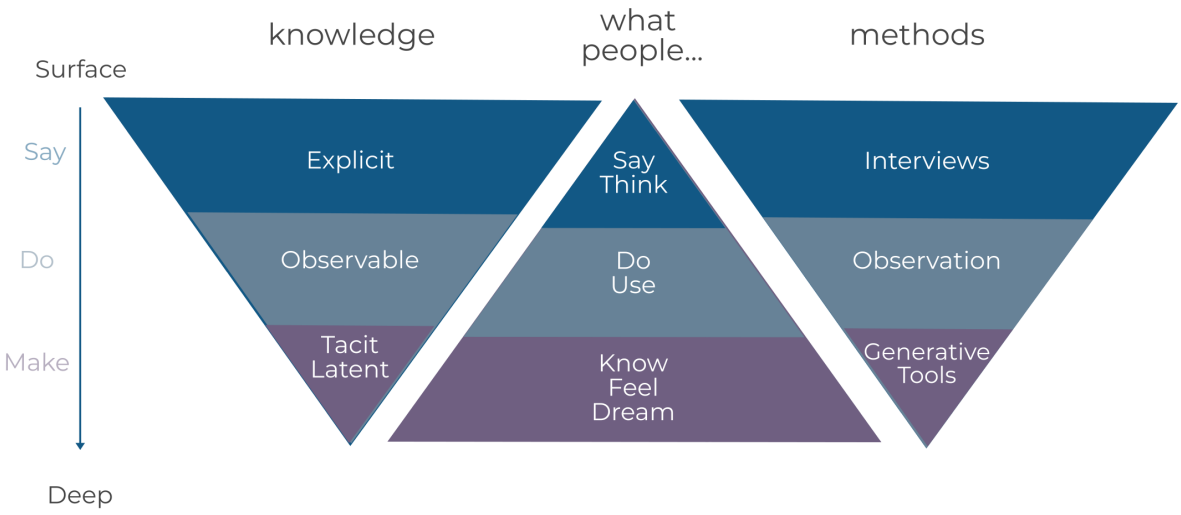

Figure 2.12 Say, Do, Make Model, adapted from Sanders, 1999.

This uncovered the families' real issues and needs for communication. To ask someone a question will normally get you an answer, an answer the interviewee thinks is correct, they make assumptions about themselves of how they would react in certain situations, from knowledge of their character, their values, and drawing on past experience in similar situations. If you observe them doing what you ask you may get different results, they may do things in a different way or a different order. They wouldn't have been purposely misleading you when they answered how they thought they would react, sometimes it is just hard to know or remember exactly. Saying and doing will allow information, that can be rather predictable, however to truly understand someone's actual needs or reactions they need to make, this uncovers latent needs, things that they could not put into words, feelings and ideas, their true needs (Sanders and Stappers, 2012).

To gain a surface understanding of user needs (families in the case of this research), it is important to listen to what they say, usually through interviews (structured or unstructured), Observe what they do, through direct observation (ethnography), diary studies (where users note down thoughts, feelings and responses to situations), or through

other probes or games (packs that are given to participants to gain an understanding of their daily lives and rituals/feelings on a topic). However, to gain a deeper understanding of user needs researchers have to begin to understand how they know things (tacit knowledge), feel things and dream or imagine the future. This starts to uncover latent needs and can be done through making activities such as generative toolkits (A kit, normally used in workshop or focus group settings, comprising of objects such as worksheets, pens, paper, scissors, glue, post-it notes, and objects that are relevant to the discussion).

2.6.1.2 Use of Interviews

We interview because there are some things that cannot be derived directly from observation. Thoughts, feelings and intentions on situations are difficult to know or understand, as is information about past events. Thus, questioning and discussion on topics allows us to gather information on thoughts feelings and intentions, enabling us to understand and gather pieces of a complete story (Gillham, 2000 and Patton, 2015). Interviews offer the researcher control over the direction of enquiry, which allows them to answer specific research questions or problems. However, it is important to be "*open-minded*" and allow conversations to flow where the interviewee wants to take the discussion, as this will provide sometimes unexpected and rich data sets (Gillham, 2000, p3).

Thus, *Informal Conversational Interviews* (use of general topics to direct flow of conversation) were combined with an *Interview Guide* style (specific questions), which allowed for more depth to be explored within certain topics at the time of discussion. This allows for key topics to be covered whilst providing the freedom to dive deep into ones that become valuable through the conversation. This mixed method interviewing style may uncover information that was not foreseen by the researcher, which can lead to unanticipated data and more focussed analysis of the key issues presented (Patton, 2015).

As each family had different experiences and separation issues, for consistency all were given a standard introduction, as well as standardised topics at each interview throughout

the process. They were always reminded that there was no 'right' or 'wrong' answers to any of the lines of questioning, that the questions and topics were chosen to understand their experiences and needs. The families were always given the opportunity at the end of each interview to offer any other thoughts that may have been missed, needed further iteration etc., in the general discussion. Allowing participants to have the "*final say*" often affords rich data (Patton, 2015, p379).

It is essential for the interviewee to feel comfortable and open to the line of questioning. It is the researchers job to create a safe space that will allow the interviewee to speak freely and honestly about the topic. Thus, interviews were conducted either in the family home or Dundee University, depending on the families wishes, throughout each stage of the project.

2.6.2 Established Methods and Methodology in Textile Design

Historically, textile designers have focussed their methodology on self-practice, and qualities of the materials and experience of their cloth (aesthetics, tacit experience, and functionality) (Igoe, 2010). The shift in methodology, using participant focussed methods over personal practice and reflection, allows textile designers to use their understanding of craft and cloth in a new way, focussing on social change and real-world problems, using the nature, aesthetics and beauty of cloth to empower others within a participatory mind-set. This way of working is common place in the world of product design, and the product designer, understanding and working inclusively with users and other disciplines to solve design problems. By borrowing these methods textile designers can work in a new participatory way expanding the limits of their design process while empowering others (designers and non-designers) to do the same (co-design). This shift in practice and thinking for the textile designer, from self-motivated (coming from their own ideals and perspectives), to a participatory mindset is vitally important to the development of wearable technologies and smart textiles (Dieffenbacher, 2013). This will continue to push the boundaries of possibilities and development within the area. Textiles offer the perfect platform to integrate and humanise technologies (wearables), due to the tactility and tacit characteristics of the cloth (Fairburn, Steed, and Coulter, 2016). Textile designers are now

beginning to see the value of including the user within their design process, as this can have positive effects on social and cultural issues (Gwilt, 2013 Ballie, 2014, and Bugg 2009).

2.7 Summary of the Literature

Technology should not be viewed as a barrier to intimate communication and family bonding; instead it should be used in a way that will allow families to communicate in an effective way that encompasses everyone's unique needs of the communication. Through use of an inclusive methodology that places the families at the centre of the process, giving them freedom and control over the design of their communication objects and systems, the researcher hopes to build intimacy and connection with family members through the communication objects and systems created.

How we view communication technology and what the perception of what communication technology should look like needs to shift. A successful communicator does not need to be housed in metal or plastic, have a screen or key pad, nor must it have an Internet browser. What then should it look like? Research suggests that by allowing the meaning, aesthetic, and personalisation of an object to become as important as the technology, people will have a deeper connection to the object. This will result in higher levels of intimacy being possible when interacting with the object (Wallace, 2007, Olivier and Wallace, 2009 and White *et al*. 2013).

21st Century families can take on any form and be made up of diverse combinations of biological and non-biological groupings of people. Through understanding what a 21st Century family looks like, this allows the problem of family communication in the 21st Century to be defined, as well as indicating what types of families to include in the research. It is the quality of communication that connects families, not the quantity (Junestrand and Tollmar, 1998; Harasim, 1993; Tollmar, Junestrand, and Torgny, 2000). Thus, this research explores how we can create more intimate family communication systems than are currently available, for use with today's 21st Century families.

Through the literature reviewed, it was found that there was a lack of research looking into non-screen-based communication devices and systems for children integrating play and

intimacy. Particularly, there was no evidence of research looking specifically at pre-school children (5 and under). All of the research being undertaken, such as the Share Table (Yarosh, 2012) and Family Portals (Judge *et al*. 2011), focussed on creating similar environments in each home. These types of static communications do not allow for the types of 'ad hoc' communications, that happen frequently over the day, which were shown to be preferred within family communications, over singular longer communications.

Other projects that were mobile such as Peek-a-boo (Neustaedter and Judge, 2010), and Story Play (Raffle *et al*. 2010), embedded video chat into story time, again targeted specific times of the day, such as bedtime when a story is traditionally read.

Within all of these communication systems there was a unification of the communication devices, meaning that they offered both parent and child the same type of communication object. They all used screen-based technologies and channels such as Skype or other video chat software that were all in real time. They also offered only two modes of communication; two-way video chat for systems such as Share Table (Yarosh, 2012), and in the instance of Family Windows (Judge, Neustaedter, and Kurtz, 2010), an observational 'window' into the lives of the child. The latter focussed more on the adult's requirements to monitor their children's basic needs and happiness and did not take into account the diverse needs of the child in terms of intimacy and control over their communications.

Thus, this research looked to bridge the gap within communication object research for children. Focussing specifically on communication objects that offer non-screen based and ad-hoc communication approaches for children aged 4-8 years old. The research project seeks to investigate if these types of communication objects would be more appropriate for the children to use and understand their needs for communicating with their parents.

Key Learning from Literature:

1. Assessing Experience:

The literature indicates it is important to not only listen to the families' sayings but also to observe their doings and understand their relating's per Kemmis, McTaggart, and Nixon

(2013). This method of data collection offers a clear overview of the participant families values and relationships, helping me to empathise with their situations and to better understand their needs.

There are many ways we can learn from people about their memories, their current experiences and their ideal experiences. We can listen to their sayings, we can observe and interpret what they say and do to uncover what they know, and we can also move past their sayings and doings and try to understand their relating's and what they feel (Table 2.1). In doing this we can start to understand what people dream (Sanders and Dandavate, 1999).

Table 2.1 Say, Do, Make Model

PEOPLE	ACCESSIBILITY	METHOD
say	Explicit *knowledge*	Interviews
do	Observable *experience*	Observations
make	Latent *needs*	Participatory Generative Methods

Table 2.1 Say, do, make model (Sanders and Dandavate, 1999)

Other important discoveries taken from the literature, and used throughout this research were understanding Attachment, the bond between parent and child, the use of symbols in communication, the several types of intimacy that is present in relationships, and the use of play especially construction and symbolic play.

These ideas reflected how the methods were used and through the families' sayings, doings and relating's (within the interviews and workshops), shaped the research questions, aims

and objectives, per the Participatory Action Research Methodology. Through understanding the different types of intimacy, the say, do, make model (Sanders, 1999) was used to embed intimacy within the communication objects through the design of the Trace communication system.

Participatory design is sometimes criticised for focusing too much on what users say. The say, do, make model allowed me to look at what the families say, but also what they do and how they make. This allowed the families to not just talk about their communication issues, but also act out scenarios and make lo-fi prototypes.

This uncovered the families' real issues and needs for communication. To ask someone a question will normally get you an answer, an answer the interviewee thinks is correct, they make assumptions about themselves of how they would react in certain situations, from knowledge of their character, their values, and drawing on past experience in similar situations. If you observe them doing what you ask you may get different results, they may do things in a different way or a different order. They would not have been purposely misleading you when they answered how they thought they would react, sometimes it is just hard to know or remember exactly. Saying and doing will allow information, that can be rather predictable, however to truly understand someone's actual needs or reactions they need to make, this uncovers latent needs, things that they could not put into words, feelings and ideas, their true needs.

2. Creating Intimacy:

Intimacy was explained through the literature to mean feelings of cohesion and connection, a deep sense of caring and compassion, thinking about and having an awareness of loved ones, sharing values and goals as well as a process of exchange or interdependence.

The research questions along with the aims and objectives of the research looked to understand how and if mediated intimacy could be achieved through smart textile and wearable technology when combined with a co-design approach.

Intimacy was built into the research in both the design of the communication systems, through the co-design of the communication objects, which happened through making within the workshops and through physically using the communication systems, in the user testing phase of the projects discussed (see Chapter 4; Small-scale studies and Chapter 5; The Trace Project).

The preceding literature has identified an opportunity where further collaborative research and design exploration spanning textiles, HCI, and engineering, could advance the exploration and design of family communication objects and systems, focussing on research and product development.

Table 2.2 Creating Intimacy

	PHASE - Activities	PHASE - Interaction
Action	**Generative Toolkit**	**User-testing**
How intimacy was achieved	Construction Play	Co-design of the object/system (family bond / memories of creation)
	Co-design of object/system (includes features, material, object type, functionality)	Tailored Interactions
		Ad-Hoc Communications
		Heightened Awareness / Feeling of Presence (due to object)

Table 2.2 Creating Intimacy

It is established that easy to use, safe and secure technology platforms would allow families to engage in communications when they are separated. Typical everyday communication

systems such as email, telephone and text messages that work effectively in the business world are somewhat lacking in terms of personal communication. Therefore, these types of communication systems have been deemed unsuitable for family communication due to usability and intimacy issues. 'Non-intimate communicators' can be difficult or awkward for children to use, and have been found to leave users feeling lonely, cold, and distant from each other (Turkle, 2012, Baym, 2010 and Freeman, 2009).

The human element of the technology is key when designing for families' communication needs, therefore it is not what can be created that matters (newest, fastest technology), but instead the ways in which it can enhance and enrich lives, through the knowledge created via the co-creation of prototypes (hardware and software) that deliver emotionally intelligent solutions for family communications. Prototypes provide a prop for "further engagement" with the families, through the exploration, testing, describing and playing with the prototypes (Jones, 2009, p116).

Design offers technology emotional intelligence (Goleman, 1998 and Norman, 2004). A Participatory Action Research methodology offers a framework of methods and processes that aids in the design of emotional family communications through co-creation. Thus, the correct communication technologies, modes of communications, interactions and objects can be designed offering the families meaningful and useful communication systems and objects. The significance of this change of thinking is that technology becomes thoughtful and empathetic to users' needs and not solely preoccupied with task management and efficiency.

3. Co-Design:

Children are often left out of the design process (Druin, 2005), however, Ólafsson, Livingstone and Haddon (2014), are calling for a multi-method, multidisciplinary, collaborative processes, which includes children in qualitative studies on their use of communication technologies. This will allow researchers to understand, how and why children use these technologies, highlighting safety and other issues that are apparent from

their use.

Thus, when working with families, children must be included as co-designers and co-creators, within the participatory process, and not seen as just the 'testers' of the technology. Extensive field work is needed, that will provide several data sets, that can be analysed to give a clear picture of the children's families 'sayings', 'doings', and 'relating's' (Jensen and Skov, 2005, Druin, 2005 and Kemmis, McTaggart, and Nixon, 2013) (see Section 3.3 *Participatory Action Research in Social Research* for information on Kemmis, McTaggart, and Nixon's (2013), 'sayings', 'doings' and 'relatings').

4. Value of Textiles:

Designers and technologists have started to see the relevance and value that textiles and fashion can offer to markets such as health (health monitoring clothing and accessories), sport (performance sports apparel) and protection (police, fire and military use). However, there is still a gap between the confluence of technology and textiles, as both sides struggle to meet emotional and physical needs of the user (Fairburn, Steed, and Coulter, 2016 and O'Mahoney 2011, Dunne 2010). To bridge this gap Dunne (2010) and Oliver *et al. (*2009) advocated the combination of practices and methodologies. Finding ways to bridge the gap such as common language (no technical or subject specific jargon) and valuing everyone's opinions and skillset can help with this process. Working specifically with the users of products, and including all involved (designers, technologists and engineers) in the idea generation phase (workshops, conversations, interview) will also help all involved to understand what the true needs and motivations of the users are. This will ultimately help focus the solution on the real needs of the user, and not what is possible with the technology available (simplifying solutions where necessary). It is also prudent for textile designers to expand their knowledge within technology and engineering ('computational' and 'science elements'), which will allow them to integrate and contribute fully to a multi-disciplinary project (Fairburn, Steed, and Coulter, 2016).

CHAPTER 3: Methodology

3.1 Introduction to Methodology

The research discussed throughout this thesis is design-led and focussed on co-design methods and prototyping through an Action Research methodology, specifically Participatory Action Research.

Paradigms within textile design are shifting; no longer are fashion and textile designers solely focussed on producing beautiful cloth to cover the body, for practical or aesthetic purposes. Fashion and Textile designers are now working in a cross disciplinary way, considering social issues such as communication and fashion consumption (The Emotional Wardrobe, 2004 and 2005), mental health (The Internet of Soft things, 2014), and healthcare (Second Skin, 2016). As wearable technology and smart textile become more common place, Stead *et al*. (2004, p282) call for a 'multidisciplinary framework' that will allow textile and fashion designers to borrow methodologies and methods such as those found within social science (e.g. *thematic analysis* (see Section 3.1.2.1), *ethical practices* (see Section 3.3) as well as *collaborative methods* such as *co-design and participatory design* (see Section 2.4.1). These types of methodologies have become common place in design disciplines such as service, product, and interactive design, where designers focus on their users to produce services, products, and interactions (Stead *et al*. 2004, Stead, 2005, Flynn and Foster, 2009, and Ballie, 2014). Therefore, these methodologies seemed appropriate to use within the research discussed here, because it allowed for active collaboration at each stage of the design process (planning, acting, observing, and reflecting).

Participatory Action Research within this research was:

- Concerned with improving intimate communications in family communication Systems.
- An iterative process, using design facilitation and co-creation methods.
- A participative process to enable families to actively engage with the process and create the outcomes.

- A qualitative research methodology.
- A reflective process to iterate, refine, and learn from each interaction.

3.2 Research Strategies: Participatory Action Research

As explained in the Literature Review (Section 2.4 *Participatory Action Research*), Participatory Action Research is a qualitative research methodology (MacDonald, 2012) often referred to as Action Research (Walker, 1993) or a 'subset' of Action Research (Gillis and Jackson, 2002).

3.2.1 Action Research

Action Research is unique in its mode of data generation, it rejects the outside 'expert' helicoptering in to solve a research problem, or question, and instead includes and listens to the beneficiaries of the research. This means the people who the research is for are the ones who drive it (i.e. the research questions, processes, as well as evaluating the outcomes, products or services the research provides) (Kemmis, McTaggart, and Nixon, 2013). As a qualitative research methodology, it combines methods such as 'observing' (through workshops, interviews, prototyping, user testing), 'documenting' (through photography, self-reporting, interview transcripts, worksheets), 'analyzing' (through thematic analysis, interview transcripts, diary studies) and 'interpreting' (reports, suggestions, prototypes) (Gillis and Jackson, 2002, and Leininger, 1985).

This type of qualitative research views the research problem through the eyes of the participants involved, which within this research context are families. This allows for discovery through the exploration of the families' experiences and not through the researcher's assumptions. Participatory Action Research allows the research to focus on the families' individual 'feelings' and 'views', outlining patterns of their communication needs without the researcher 'controlling' or 'manipulating' the results (Leininger, 1985).

There are varying reasons a researcher will choose to follow any of the Action Research methodologies. Carr and Kemmis (1986) recognise several kinds of action research based

on Habermas's (1972, 1974) theory of knowledge-constitutive interests, such as technical action research (to improve control over outcomes), practical action research (an interest in educating or enlightening practitioners) and critical action research (an interest in emancipating people and groups from irrationality, unsustainability, and injustice) (Kemmis, McTaggart, and Nixon, 2013 p14).

Participatory Action Research allows collaboration through the chosen methods (Hall, 1981), therefore the participants can 'own the discourse' and 'seize the power' within the research study (Herbert, 2005), resulting in their becoming true co-researchers. There are two main aspects that Participatory Action Research cover (Kemmis, McTaggart, and Nixon, 2013, p4). These are as follows:

1. The recognition of the capacity of people living and working in particular settings to participate actively in all aspects of the research process.
2. The research conducted by participants is oriented to making improvements in practices and their settings by the participants themselves.

For a successful Participatory Action Research methodology, participation of the end users (in this case families separated by illness, work or family breakdown), must be active in every key stage of the design process (planning, acting, observing and reflecting), and motivated to positively change their problems, in this case, improving family members' communication when separate (Kemmis, McTaggart, and Nixon, 2013). Walker (1993) agrees the Participatory Action Research methodology plays a crucial part in engaging people to effect change within their communities.

3.2.2 Participatory Action Research in Social Research

Participatory Action Research is different from other types of social research because it has "*change and action as an embedded and critical element of its approach*" (Walker, 1993). Per Reason (1998, p71) it offers researchers a duel approach to research:

1. It produces **"*knowledge and action*"** for the participants of the research.

2. It **"*empowers*"** the participants to use **"*their own knowledge*"** to provide solutions to issues they are facing.

The relevance and value of Participatory Action Research comes from the original hypothesis, considering factors such as: "*is the research useful?*", "*how has this been determined?*", "*is there evidence to support this?*", "*has the hypothesis been checked/tested in practice?*" (Wadsworth, 1998, p5). These factors were fundamental to the development of this research, and became integral factors in shaping the main research questions (see Chapter 1, Section 1.2 *Research Questions* and *Aims and Objectives*).

Kemmis, McTaggart, and Nixon, (2013), go on to propose that through Participatory Action Research the researcher can (Kemmis, McTaggart, and Nixon, 2013, p5):

1. **"*understand and develop the ways in which practices are conducted 'from within' the practice*" -** allowing researchers to understand how to use and adapt methods to yield the desired results.
2. **"*speak a shared language*"** - helping with the communication of all co-designers (designers and non-designers).
3. **"*can participate in and develop the forms of action and interaction in which the practice is conducted*"** - to become an active facilitator and a co-designer, whilst being flexible as to which role is needed within each phase of the design process.
4. **"*can participate in and develop the communities of practice through which the practice is conducted, both in the relationships between different participants*"** - build trust and strong relationships with all involved within the research (participants, designers, researchers, technologists).
5. **"*can both individually and collectively, transform the conduct and consequences of their practice to meet the needs of changing times and*

circumstances" - evolve working patterns, language and methods to suit the shifting roles and goals within the research project.

Several different methods were employed at each stage of the research to capture each of the family's actions surrounding current communication practices, communication needs and types of intimacy achieved. These actions have been categorised as the families:

- ***Sayings*** - what participants think and say in relation to their communication needs and current communication methods.
- ***Doings*** - what participants do, how they communicate, and types of intimacy achieved.
- ***Relatings*** - how participants relate to others and the world through their chosen communications, and types of intimacy achieved.

(modified from Kemmis, McTaggart, and Nixon, 2013, p20)

For example, interviews, co-design workshops, worksheets, observation and self-reporting were some of the methods used to gather the families' 'sayings'. Co-design workshops, participant prototyping, worksheets, diary studies, and observation, all allowed for the researcher to understand the families 'doings'. While user testing, interviews, diary studies, and self-reporting were all used to understand the families 'relatings' (see Section 3.3.2 *Methods Used in this Thesis*).

3.2.3 Participatory Action Research Process

The Participatory Action Research process is a recurring approach of planning, acting, observing, and reflecting. It is not an individual round of design. It is a repetitive and iterative process, with layers of research, development, testing, and reflection. This process is repeated until the desired outcome is achieved. (Turnbull, Friesen, and Ramirez, 1998).

This cyclical approach is displayed in Figure 3.1.

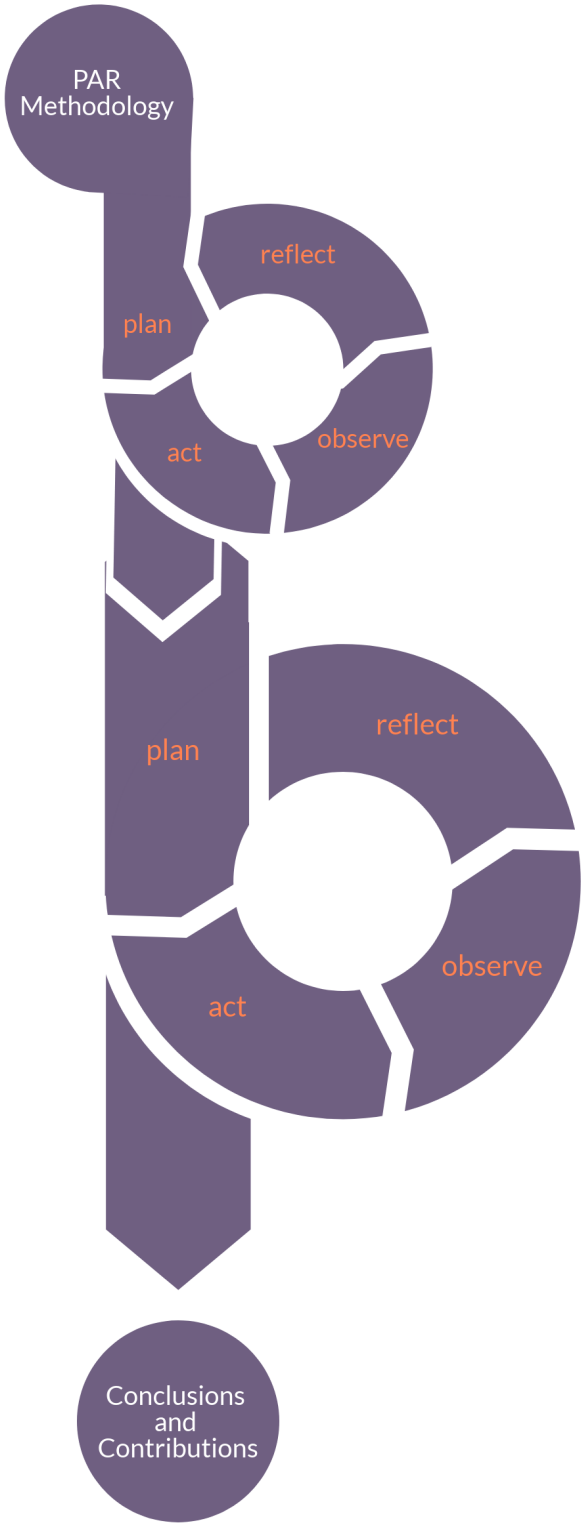

Figure 3.1 Participatory Action Research (McNicoll, 2017). Adapted from Kemmis and McTaggart's Action Research Spiral (2000, p595).

3.2.4 Ethics

When entering any type of participant focused research, it is essential to build trust and relationships with participants to generate quality data (Hirschman, 1985, Vines *et al*. 2013 and Waycott *et al*. 2015). This can be done through listening, discussion, fun activities, and showing empathy and understanding to participants. When people feel heard and their opinions are valued, more quality data will be able to be gathered as they will feel safe, understood, and will offer truer accounts, views, thoughts, and feelings (Reason and Bradbury, 2001, Sanders and Stappers, 2014, Ricard, 2015 and Sanders, 2017).

Thus, ethical approval was required, sought, and granted by the University of Dundee's Research Ethics Committee (Appendix 1). The University of Dundee adheres to the following ethical guidelines for working with vulnerable user groups. These are as follows:

- Participants must give informed consent.
- Participants should not be harmed by the research in any way (physically or mentally).
- Participants should be made aware that participation is voluntary.
- Participant confidentiality must be adhered to at all times.
- Participants should suffer no consequences if they withdraw from the research at any stage, for any reason.

Ethical procedures and principals exist and are enforced to protect the welfare of everyone who takes part in the research; both the families and researcher (Moncur, 2013 and Waycott *et al*. 2015). Thus, since Action Research is deployed in the real world, through everyday contexts and relies on the familiar, honest, and open communications among all involved (families and researcher), it is essential for researchers to diligently adhere to the ethical guidelines when conducting their research (Winter, 1987 and Vines *et al*. 2013).

Kemmis and Mctaggart's Ethical Principles In 'Action Research' (1981) were acknowledged and adhered to by the researcher, ensuring the transparency of the research to all involved, reporting progress, and involving participants at each key stage during the research process

and feeding back where appropriate.

It is vital to adhere to a strict guideline of ethical conscience when working with participants (Kimmel, 1998). In this research study Kimmel's ten questionable practices in social research were taken into account. The researcher carefully constructed each exercise and communication with the families, making them feel relaxed and at ease. It was essential to acknowledge and respect each family member's social cues when working in such an ad-hoc manner, to ensure that no undue mental stress was placed on any of the participants (especially important due to the sensitivity of the subject themes explored in the research) (Vines *et al*. 2013).

Kimmel's principles were diligently followed in this research, everything participants were asked or expected to do was outlined clearly in participant information sheets, and the families consent was gained before any member took part. All participants were actively encouraged to ask questions and enter discussions on a regular basis about the investigation with the researcher. By taking this approach it helped the participants to have a clear understanding of what was happening during each stage of the research or task, which allowed for more opportunity to refine ideas and gain a deeper level of understanding of the participants' needs, wants, and desires.

Per Winter (1987) and O'Brian (1998), there are five key ethical principles that must always be acknowledged and adhered to when undertaking Participatory Action Research. These are as follows:

1. The researcher must consult all stakeholders involved with the research (participants, governing bodies, institutions), before the start of the research project.
2. Every participant should have equal opportunity to influence and contribute to the research. If participants no longer want to be involved or do not wish to contribute to certain aspects of the research, these wishes should always be respected.

3. The research should be visible, transparent and easily accessible by the participants, allowing them to aid in the development of ideas and processes.
4. Due to the shared ownership of the research, the researcher must ensure permission is sought from all participants before disseminating or publishing the work.
5. The researcher should make sure all personal information remains anonymous and confidential.

Further to Winter (1987) and O'Brian (1998), five ethical principles in Participatory Action Research above, Mac Naughton *et al*. (2010) values and principles of early childhood research were also observed. This was essential as this research worked with families, which included young children (aged three to nine). The research must be:

1. *Critical and political*
2. *Ethical*
3. *Respectful of the children's participatory rights*
4. *Purposeful*
5. *Well designed*
6. *Transparent*
7. *Honest*

As this research focused on family life, communication, and young children, more stringent ethical regulations and guidelines were needed to protect the vulnerable participants involved (children). Thus, the methodology was driven by the constraints put in place to protect individuals who are not always able to give informed consent (e.g., children and people with disabilities) (Foss, Guha, and Druin, 2014 and Vines *et al*. 2013). This was particularly significant when working with the Children's Hospice Association Scotland (CHAS within the KIST project, small-scale study 4; Chapter 4; Section 4.3.4).

3.2.4.1 Child Participants

The child participants of this research came from 20 different families who were separated by divorce, work travel, and illness, and who ranged from three to twelve years old (see Chapter 4, Section 4.1 *Introduction*, for a breakdown of the participating families).

It has been previously thought that children were too young or naïve to be able to give informed consent when undertaking research (Brock *et al*. 2010). However, Druin (2009), has found that children can be successfully included through an entire research process as collaborators and co-designers, providing certain ethical principles are followed, and that they are respected, and their needs are met (Yarosh, 2014).

Children, like adults, were also interested and their input was required in the development and outcomes of the research. It was therefore important to include them in the whole process. Children were not only subjects during idea generation (through co-design workshops and discussions) and during user testing, but were 'active participants' for the whole process including the planning and reflection of the research. When family members, be they adult or child, are actively engaged in the whole design process the research, development, outcomes, and findings form a robust account of the process offering focused outcome(s). These resultantly are based on the actual needs of the users and not on the designer's reflection (projection) of what they imagine them to be. Full engagement and inclusion of all family participants then, was needed to give a full and cohesive account of each individual family member's wants, needs, and desires, along with genuine feedback on the communication objects and systems created. This information, collected at each stage of the research process (planning, acting, observing and reflecting) from the families' sayings, doings and relating's, is essential for later analysis of the research data. This ensured that a truer account of the research was disseminated as information could be crossed reference through the analysis of the separate data sets.

3.2.4.2 Informed Consent Procedure

The research discussed in this thesis was conducted with twenty participant families spanning the small-scale studies and the main study. Table 4.1 in Chapter 4, Section 4.1,

offers a breakdown of the families who took part, including the parent to child ratio. Most of the research was conducted in the participant families' homes, as this provided a safe and familiar atmosphere where the families could discuss their separation issues and identify ways in which these could be improved through technology (Moncur, 2013).
Parental and child consent was gained through participant consent forms and vocally (Appendix 1), as per ethical procedures when working with families who have young children (under 16) (Yarosh, 2014 and Foss, Guha, and Druin, 2014). This adhered to the University of Dundee's and Kimmel's ethical requirements (University of Dundee, 2017 and Kimmel, 1998).

However, when working on the KIST project (see Section 4.5, *Small-scale study 4*), at the Children's Hospice Association Scotland (CHAS) in Kinross, full enhanced disclosure Scotland checks were required (mygov.scot, 2017) as well as the University of Dundee's Research Ethics Committee (Appendix 1). This was because the KIST project included children who often could not offer informed consent, so fell under the category of vulnerable users (mygov.scot, 2017 and University of Dundee, 2017). Thus, ethical clearance from the hospice staff, as well as the children's parents, was sought before undertaking the research.

3.2.4.3 Privacy and Confidentiality

The privacy of the participant families along with the confidentiality of information shared was of upmost importance. This offered the families reassurance that their personal data would be handled sensitively and stored securely, aiding family engagement and willingness to be part of the research.

The University of Dundee's Research Ethics Committee guidelines (University of Dundee, 2017) states that data (audio and visual), can only be kept for a pre-determined time, per principle 5 in the data protection schedule (University of Dundee, 2017). It was agreed at the start of this research, with the University of Dundee's Research Ethics Committee and the participant families, that their data would be held for up to three years in a secure place (password protected hard drive for audio recordings and a locked filing cabinet for physical

artefacts, drawings, and participant worksheets), and then would be destroyed. This adheres to the Data Protection Act 1998 (GOV UK, 2017), and ensures the anonymity of the participant families involved.

Thus, all audio recordings and physical artefacts (such as participant worksheets, lo-fi models and prototypes, drawings) made by the families, have now been destroyed. The physical 'makings' of the participants were photographed and can be found in Appendix 4, along with the conversational data logs Appendix 3.1, and interview transcripts Appendix 4.10.

However, consent was not always given by the families to audio record discussions, and in some cases, was not sought because this type of recording is more obtrusive than a notepad and pen (Atkinson, 1981 and 1997, Armstrong, Gosling, Weinman and Marteau, 1997 and Atkinson and Pugsley, 2005). The main concern over using audio recordings was that the families would not speak openly and honestly when their 'sayings' were being recorded (Armstrong, Gosling, Weinman and Marteau, 1997). Audio recordings often make people uncomfortable, as they worry about the importance of their 'sayings', the sound of their voice on tape, and safeguarding their anonymity (Hammersley and Atkinson, 2007 and Sutton and Austin, 2015). It was vitally important, in workshops and interviews, that the atmosphere was relaxed and welcoming. Thus, it was decided not to audio record the co-design workshops or interviews in the Trace project, and instead to write down key points (in the participant's own words and language styles) on post-it notes or large sheets of paper, to capture the discussion. This also allowed the families to remove or change thoughts (remove post-it notes or score through text) as the conversations progressed.

Photography was used as a method of documentation during the co-design workshops and user testing sessions, both by the researcher and the participant families. This type of documentation, is a more familiar and accepted method of recording participant data by the families involved (Bryman, 2015 and Armstrong, Gosling, Weinman and Marteau, 1997). Especially, over the past decade with the adoption of social media sites such as Facebook and Instagram, where people continuously document their lives through images (Jensen, 2014, Burns, MacLachlan, and Rees, 2016 and Sheldon and Bryant, 2016).

3.2.4.4 Ethical Considerations of the Researcher

The mental wellbeing of the research team is also an important, and often neglected, consideration when working in sensitive contexts such as family separation and child illness, especially when these children have limited life spans (such as at CHAS) (Malacrida, 2007 and Moncur, 2013), many of whom will not reach adulthood (CHAS, 2017). These sensitive contexts are illustrated in the CHI 2012 workshop "Memento Mori: Technology Design for the End of Life" (Massimi, *et al*. 2012) where researcher's emotional responses to sensitive research topics and live research are discussed. These emotional reactions can cause issues with research findings and the dissemination of the results in qualitative research (Malacrida, 2007 and Moncur, 2013). Thus, it is important to put ethical procedures in place that protect not only the participants of the research, but the researchers as well. This safeguards the wellbeing of the researchers and allows for more accurate qualitative reporting of the research findings (Malacrida, 2007, Massimi, *et al*. 2012 and Moncur, 2013). This was achieved by "*an engaged reflexive approach that ensures not only ethical approaches to interpreting the lives of others, but also the emotional safety of research team members*" (Malacrida, 2007, p1130).

During the research the researcher's life changed drastically, with the birth of her two sons, which gave her a new outlook on family separation, and a deeper empathy and understanding for the participant families. These first-hand family experiences, allowed the researcher to re-evaluate her ethical stance and have a deeper connection to the data that the participant families shared, allowing her to treat their stories with more care and attention. While it was a concern that having her own family would compromise her impartiality in the research, the experience of motherhood enabled the researcher to have a deeper understanding and empathy for their situations, and allowed her to focus and understand their 'sayings', doings' and 'relatings' in a more considered way. Wheatley (2005), recognises the connection a researcher can have with their participants, when they share similar life experiences. This connection enables researchers to become more empathetic researchers, which will allow for more considered analysis of the research data collected from participants (Wheatley, 2005).

3.3 Research Methodologies and Methods Adapted in this Thesis

As previously discussed, a participatory action research methodology was followed to allow for the co-design of family communication systems. The cycles of research can be seen in Figure 3.2. Several iterations of planning, acting, observing, and reflecting, happened through each small-scale study, resulting in the learning from each feeding into the next study, and round of research. All the data gathered from each of the small-scale studies was reflected upon and determined the method selection for the following studies (see Section 3.3.2 *Methods Used in this Thesis*), and aided in family recruitment (see Chapter 4, Section 4.1 *Introduction*). This process also gave the researcher a body of work to present for further funding, enabling the Trace project to take place (See Chapter 5, *Main Study, The Trace Project*). The process of planning, acting, observing and reflecting was repeated several times in the main study until the final Trace communication system was produced. Thus, within the large loop (Figure 3.2) several smaller loops of planning, acting, observing and reflecting took place making up the four main phases of the Trace project (see Chapter 5, section 5.4).

Technical Action research is used to expand an object or artefact's significance and value, while other strands of Action Research expand the significance and value of knowledge. (Wieringa and Morali, 2012 and Vaishnavi, and Kuechler, 2015). Participatory methods such as co-design, popular in achieving an increase of an object's importance, proposes meaning and intimacy can be created in communication objects for family communication through the process of co-design.

Objects designed and tested under controlled conditions, such as through co-design workshops, can then be developed and refined resulting in desirable objects for the family participants of the co-design workshops (Wieringa and Morali, 2012 and Hansson, 2013).

Similarly, user testing begins with a controlled demonstration of the objects, before all technical support is removed and participant families explore these objects (Trace communication system) on their own (see Section 5.5 *User Testing*). This allows the researcher to observe interactions and behaviours first hand and can add to the understanding and relevance of the system (Wieringa and Morali, 2012).

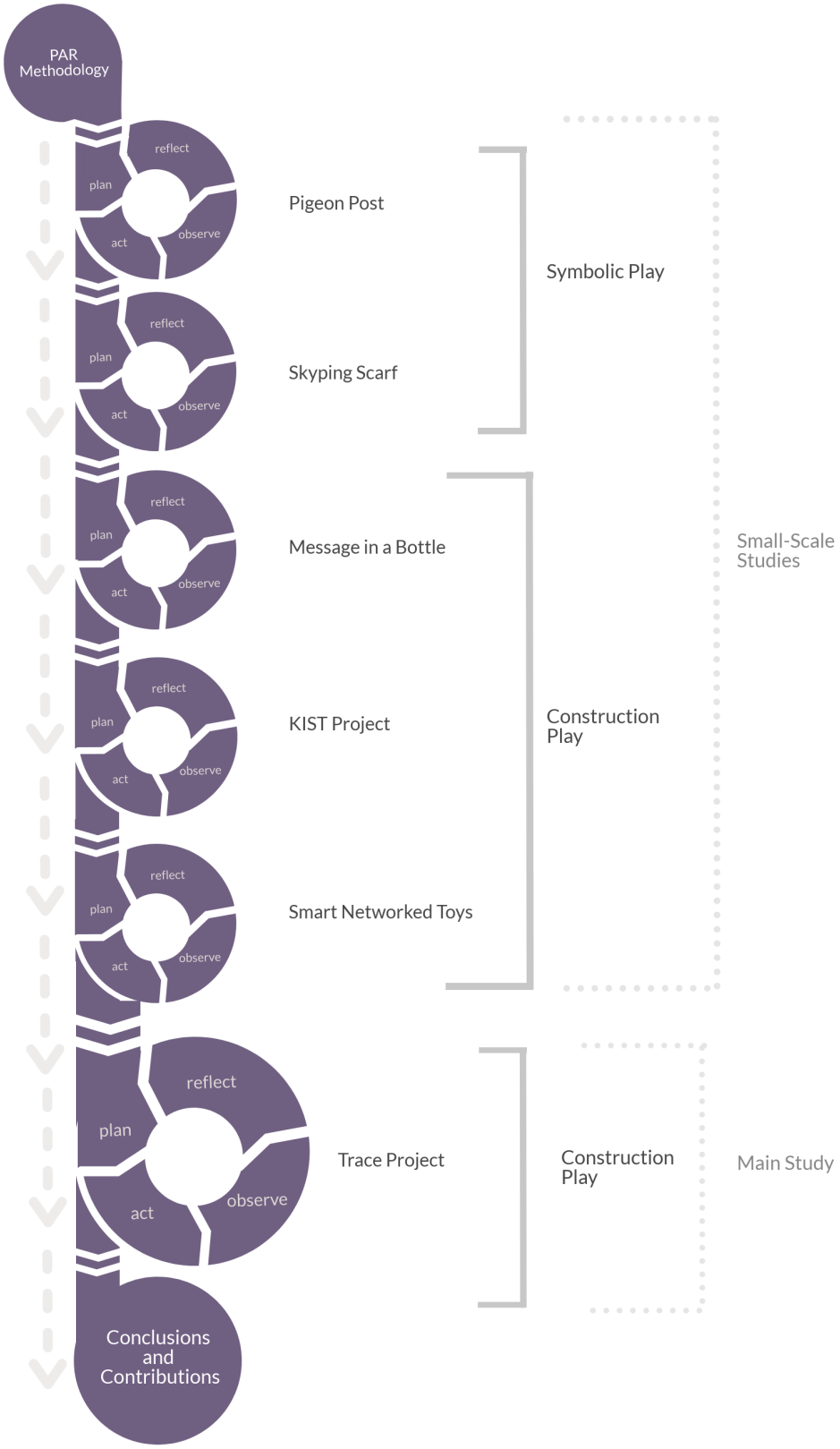

Figure 3.2 Participatory Action Research within this study (McNicoll, 2017).

3.3.1 Why Participatory Action Research is Suitable for Family Research

Participatory Action Research offered a suitable framework for research into family communication, as it is grounded in the real needs and learning of user groups (families), and democratises the process by being an inclusive methodology (allowing everyone to have a voice and opinion) (Wadsworth, 1998).

By understanding the families 'sayings', 'doings' and 'relatings' (Kemmis, McTaggart, and Nixon, 2013) at each stage of the research process, allowed the researcher to understand the families' motivations for communications, what these should look like and how these could be made.

The five ethical principles (Section 3.2.4 *Ethics*) were always adhered to throughout each of the small-scale studies and the main study within this research. This was achieved by using methods such as 1. participatory information sheets (which included detailed descriptions on the project, expectations of each party (researcher and participant), time commitments and a clear understanding that they could leave the research at any time, consent forms, discussions), and 2. consent forms (both parent and child), discussions (with whole family), verbal and written permission to use the families 'sayings', 'doings' and 'relatings' as well and photographic evidence of each (consent forms, through email, and interviews), and the anonymity of the families. However, families did give permission for the photographs taken in workshops and user testing to be published (unedited) within the thesis.

Mac Naughton *et al*. (2010), values and principles of early childhood research were also followed due to the families including young children (aged 3-9). These were adhered to in the following ways:

1. By following the families' ideas (through interviews, co-design workshops, worksheets) to ensure their needs were being met through the family communication system(s) that were created (pilot(s) and main study).

2. By ensuring the workshops and activities the children were asked to take part in (co-design workshops, probes, worksheets) were clear and user friendly, while being fun and playful (through drawing tasks, lo-fi prototyping, and user testing).

3. Ensuring that every method of collecting the families 'sayings', doings' and 'relatings' was purposeful and related back to the research aims and objectives (actively answering the research questions with every study), and that all research activities (small and main study) reflected a true account of each, and were explained clearly with the information and findings being easily accessible to the families at all times.

When Action Research is implemented effectively, it produces valuable knowledge for improving human welfare (Cornwall and Jewkes, 1995, and Heron, 1981). It is important then to understand the needs of the participants and have a relaxed nature when collecting data. When working with vulnerable user groups, or with sensitive subject matters (as was the case with this research), Participatory Action Research allows for a 'hands on' approach, meaning the families had the opportunity to generate knowledge using their own language (visual and spoken) (Kindon, Pain, and Kesby, 2008). The families explored their issues regarding communication through discussion, creative exercises (making, visualisations, drawing), and reflection (Kindon, Pain, and Kesby, 2008). This allowed the families to drive the research and future agendas, while the researcher facilitated the activities, offered general discussion points and prompted reflective practices. Therefore, as a qualitative methodology, Participatory Action Research was used to understand the families, and describe their experiences rather than predicting their needs and controlling the outcomes of the research (Streubert and Carpenter, 1995).

This process of knowledge generation offered a more robust way of understanding the families' direct needs and issues over a quantitative approach, because qualitative research methods offer a wider understanding of complex human behaviours, due to an emphasis on the individual's experiences (Lincoln, 1995 and Mason, 2006).

However, this philosophy can produce several different data streams or perspectives from each family member, meaning that there is "*no single, objective reality, there are multiple realities based on subjective experience and circumstance*" (Wuest, 1995, p.30) which can cause confusion when analysing results to make a positive change. It is then essential to look for commonalities within the participants' truths, which can happen through reflection, discussion, and making (Greenhalgh and Taylor, 1997). Having a strong framework for analysing data such as *thematic analysis* (see Section 3.5.1), offers the researcher more control over validating the data and offers rigor to this method of qualitative analysis.

3.3.2 Methods Used in this Thesis

To allow for the easy organisation and presentation of the methods used within each part of the research (small-scale studies and main study), a design facilitation toolkit was created. Design facilitation toolkits are a way of sorting and presenting methods into categories of use. There are many examples of design facilitation research which use such toolkits such as IDEO (2002, 2011, 2015), Earley *et al*. (2015), Stanford d.school (2011), and Kimbell (2011, 2014).

However, Hogan (2005, p1) refers to 'facilitation toolkits' as 'sewing boxes' and describes them as "*colourful, sparkling treasure-trove[s]*" that are "*infinite in delights*". For textile and fashion designers who do not normally use these types of methods, using a facilitation toolkit to organise methods is beneficial. Just like a physical tool box or sewing box, facilitation toolkits can be added to over the course of a project, allowing the researcher to be selective in the methods they are using for each part of the project. The same methods do not always yield the same results, much as a hammer is no use to put in a screw (Hogan, 2005). Therefore, having a range of methods available to use with different family groups at different stages of the research, and having the ability and foresight to choose the correct ones, makes for a successful facilitator, and should provide the best data for analysis.

A basic 'toolkit' of methods was created for each of the pilots and the main study, that allowed for the organisation of methods under each key stage of the Participatory Action Research process (planning, acting, observing, and reflecting). An example of this toolkit

can be seen in Table 3.1. This framework offered the researcher a basic toolkit of methods that were built upon as the research developed.

Table 3.1 Example Toolkit (summary of methods)

Stage	*Methods*			
Stage 1 (Plan)	Recruitment	Interviews		
Stage 2 (Act)	Prototyping / Generative Toolkit / Co-design Workshops	Interviews	Thematic Analysis	
Stage 3 (Observe)	User Testing	Diary Studies	Observation / Photography	Thematic Analysis
Stage 4 (Reflect)	Interviews	Thematic Analysis		

Table 3.1 Example Toolkit (summary of methods)

3.3.2.1 Plan

Within each of the small-scale studies and the main study, preliminarily planning was needed to identify which methods, processes, and techniques were needed to develop each study. The facilitation toolkit offered a 'starter pack' of successful methods (for each key stage of the research process), proven in other social research studies (see IDEO (2002, 2011, 2015), Earley *et al*. (2015), Stanford d.school (2011), and Kimbell (2011, 2014)), such as interviews, workshops, prototyping, photography and thematic analysis (see Table 3.1).

The methods were built upon and substituted for alternate methods depending on the study, the families involved, and the information that was required. For example, parental interviews were conducted at the start of each study (with new families to the research). This allowed the researcher to gain key information about the families' separation, without having to discuss issues in front of the children, that may have been upsetting for them, and aided parent-researcher bonding. Family interviews were conducted at the end of each

study to gain feedback on experiences with the prototypes, offering key information on the types of communications that worked/did not work, the objects (size, look, material, interactions), and offered a space for the families to make suggestions for future iterations. This allowed the researcher to have a better understanding of families' needs and the types of communication systems that would support their communication needs.

Primary research was undertaken before each study, visualisations and mapping exercises were used to allow the researcher to understand the key issues. The researcher also used the literature (Section 2.4.1) to identify existing methods, tools, and approaches that would be suitable in family research.

Each small-scale study allowed the researcher to test out varying social science methods (interviews, workshops, ethnography, diary studies, thematic analysis), to allow for the selection of the core methods that were to be used in the main study (see Chapter 5, Section 5.4 *Methods*).

3.3.2.2 Act

The researcher became the facilitator of the action within each study, which predominately focused on an end prototype of a family communication object or system. This action generally took place during a workshop (in the families' homes or in a studio space at the University of Dundee), where families would work through individual and group tasks answering questions about themselves (i.e. favorite colour, book, song), or take part in collaborative family making and drawing exercises, i.e. drawing their current communications, and making objects to represent how they would like to communicate.
Idea elaboration was a useful tool to use in workshops and discussions with the families, Guha, Druin, and Fails (2013) use creative toolkits called "*Bags of Stuff*" when working collaboratively with adults and children. Bags of Stuff is a "*prototyping technique in which children and adults use big bags filled with art supplies such as glue, clay, string, markers, socks, and scissors to create low-tech prototypes of technology*" (Druin 2002, Guha, Druin, and Fails, 2013, p17) much like generative toolkits which are a selection of materials for participants

to use to create paper and lo-fi prototypes, diagrams, drawings or maps surrounding a topic that was provided in the kit (Sanders, 2000). These creative toolkits or generative toolkits (including worksheets, pens, pencils, cello tape, scissors, glue) were used within workshops to aid the creative process, idea generation, and ultimately idea elaboration.

These generative toolkits resulted in the creation of lo-fi prototypes by the families, allowing them to visualise their ideas in three dimensions. They allowed them to fully think through the features their communication systems and objects should have and made it easier for them to vocalise their ideas when presenting and discussing their ideas.

Figure 3.3 shows the key information that was be gained from the families to aid in the co-creation of the communication objects and systems. This has been adapted from the dimensions of roles in the design process (Guha, Druin, and Fails, 2013, p16), and covers three key areas, 1. Research, 2. Technology, and 3. Inquiry.

By organising the information provided by the families into the three main categories of 1. Research, 2. Technology and 3. Inquiry, this aided in the development of the family communication systems, as well as with selection and adaptation of both methods and technology utilised within the research.

This learning through doing (making of lo-fi prototypes in workshops), using Sanders (1999), say, do make model, instilled confidence in the families which was evident when they presented their ideas, thoughts, and feelings about each prototype through discussion at the end of each session. The families found their voice through the making activities and came up with ideas collaboratively that they said would not have been possible through simple discussion. Offering the families, a clear goal to work through, setting out a well-defined direction and purpose of research, is good practice and allows each participant to become invested in the research (Reason and Bradbury, 2006). Therefore, by actively engaging the families, and setting out a clear rationale for the research from the beginning, offered greater research possibilities and opportunities.

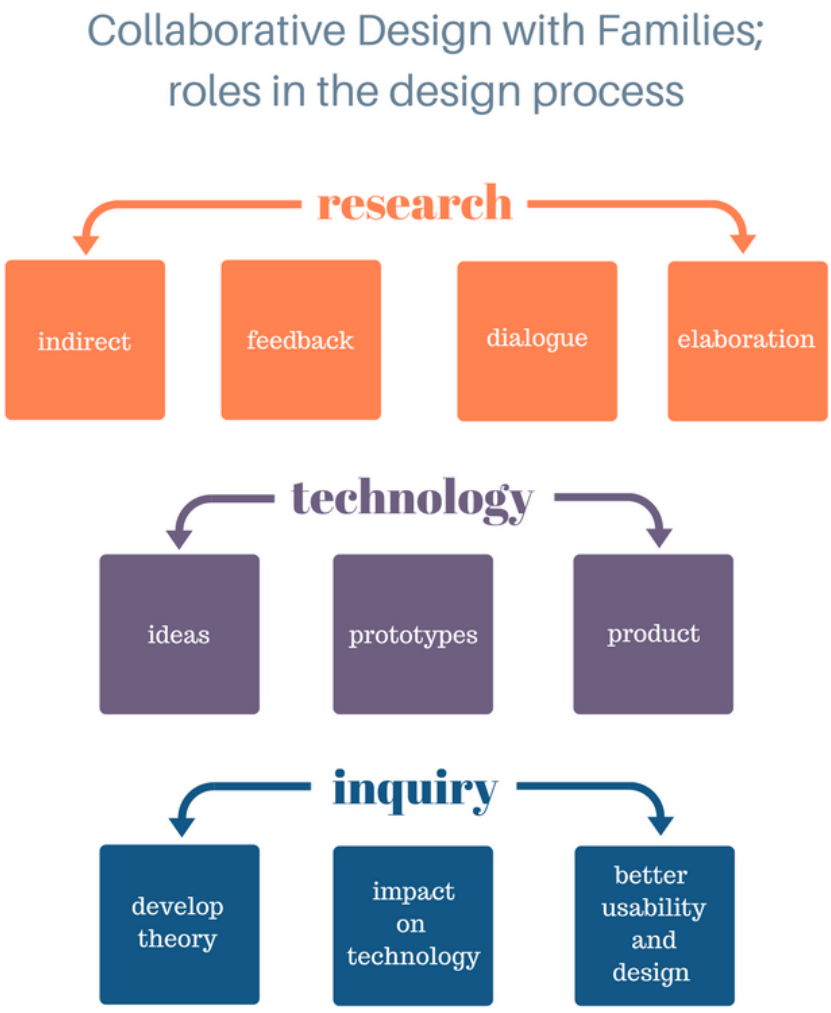

Figure 3.3 Outline of the families' roles in the design process. Adapted from the dimensions of roles in the design process (Guha, Druin, and Fails, 2013, p16).

Collaborative working was important, since it allowed for all co-designers to successfully frame the problem (remote family communication) as well as agreeing on the actions that were needed to meet their desired goals (co-design workshops, prototyping, user testing) (Rittel and Webber, 1973). Collaborative working was also used by the multi-disciplinary team (researcher and the technical experts, see Chapter 5, Section 5.3.1) who offered technical, support, help, and advice on the creation of the Trace family communication system, within the Trace project.

3.3.2.3 Observe

Through a process such as Participatory Action Research, data is collected through engagement with the families at each stage of research (through each of the cycles of action research). Thus, it is important to understand which methods will effectively collect the data required at each stage. When working with families' method identification, which will suit everyone's needs, can be problematic. However, there are certain measures that can be put in place such as: 1. familiar surroundings (i.e. conducting workshops in the home environment), as this allow the families to feel more relaxed than if they were in a more formal setting, 2. listening and understanding, being an empathetic researcher who takes time to get to know participants and designs or adapts methods to suit their needs; i.e. lo-fi prototyping; allowed the families to 'make' communication systems as a way to explain their ideas (even though they had no working technology). Parents were worried about their knowledge and understanding of technology and the costs associated with these (incase children 'broke' anything), so by giving them lo value 'junk' materials, such as cardboard boxes, drinks bottles, yogurt pots, allowed them to freely create and discuss the specific issues and needs of their families' communication, without having to worry about understanding how technology works or the associated costs.

Research observation was applied through the workshops (participatory action). It was conscious observation, used as a systematic research tool to address the research questions (Merriam, and Tisdell, 2015). It was used as part of the analysis of data sets which allowed the information that was observed to be validated (Patton, 2015).

Looking at three different data sets strengthened the study because every method has its limitations (Mason, 2006), thus by using multiple methods this allowed the researcher to study the problem from different viewpoints and validate the 'truths' from the research by observing and reflecting upon 1. what the families did or their 'doings' (observations, workshops, user testing), 2. what they said or their 'sayings' (interviews and self-reporting methods such as diaries) and 3. how they acted or their 'relatings' (how many times they interacted with the Trace communication system) (see Chapter 5, Section 5.6 *User-testing* and 5.7 *Analysis*).

3.3.2.4 Reflect

The process of reflection allows distance to be created from each experience, objectively assessing and questioning each one, resulting in new insights or the uncovering of further research questions. Reflection then, is the method that combines action and research through the Participatory Action Research process (Pedler, 2011), which allows the researcher to develop the capacity to recognise and show what they have 'planned', 'discovered', and 'achieved' through their research (Raelin, 2011).

Visual data collected through observation, user testing, self-reporting, and interviews was used to reflect on each iteration (small-scale and main study). Participant diaries and information sheets (from workshops), were used alongside pure data (family interactions with the communication systems), interviews and research observations, which provided a full picture of the families' reflections and experiences with the communication systems (outcomes of research).

The reflections from each small-scale study fed into the next study, and cycle of the Participatory Action Research process, culminating in the main study, the Trace project (see Chapter 5).

3.3.2.5 Data Analysis

As this research is qualitative in nature certain methods of analysis were used to capture the main findings throughout each of the smaller studies and main study. *Thematic Analysis* (Section 3.3.2.5.1) was used to organise information for the dissemination of findings.

3.3.2.5.1 Thematic Analysis

Thematic Analysis is "*A method for identifying, analyzing and reporting patterns within data.*" (Braun and Clarke, 2006, p. 79). These 'themes' can be used to loosely describe and organise collected data (Boyatzis, 1998). This type of analysis is used within qualitative research as it offers flexibility of method selection, and can fit into any methodological structure (Ely, Vinz, Downing, and Anzul, 1997). "*A theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within*

the data set" (Braun and Clarke, 2006, p10). Themes then are dependent on the research questions and what the research intends to discover. However, all themes will be recognised and sometimes common themes will be found that are surprising or perhaps contradictory to the researcher's assumptions of what the research questions will uncover. A "bottom up" (inductive) way of thematic analysis was used. This inductive approach means the identified themes are fully related to the collected data (Patton, 1990), resembling a grounded theory approach (Glaser, 1992).

The freedom within thematic analysis, using the inductive approach, offers the research a fluid method to collect and analyse the data. This resulted in a true representation of the families' responses within each stage of the research, aligning with the participatory nature of the methodology.

Table 3.2 Advantages of Thematic Analysis

1. Flexibility.
2. Relatively easy and quick method to learn, and do.
3. Accessible to researchers with little or no experience of qualitative research.
4. Results are generally accessible to educated general public.
5. Useful method for working within participatory research paradigm, with participants as collaborators.
6. Can usefully summarise key features of a large body of data, and/or offer a "thick description" of the data set.
7. Can highlight similarities and differences across the data set.
8. Can generate unanticipated insights.
9. Allows for social as well as psychological interpretations of data.
10. Can be useful for producing qualitative analysis suited to informing policy development.

Table 3.2 Advantages of Thematic Analysis (Braun and Clarke, 2006, p37).

Table (3.2) shows the advantages of thematic analysis, especially important to this research was: 1. The flexibility of the method (which was adaptable within the pilot(s) and main study, while allowing the researcher to draw out the key themes from each), 2. Ease of use, 4. Ease of understanding of key themes (for all co-designers; families, technologists and designers), 5. Effective method for use within a participatory methodology, 6 and 7. Offers overarching themes or more precise data sets as well as any similarities found (useful for understanding the main problems with family remote communications as well as the specific communication issues within each individual family), 8. Generation of surprising results (keeps the research relevant to family communication, focusses on the results from the research rather than the researcher's bias or preconceived ideas), 9. The other points on accessibility to early stage researchers and policy development are more key features within, thematic analysis and while important, are not essential to the research discussed in this thesis. In future research studies, it is thought qualitative analysis suited to informing policy development will be a very important factor, but not within this early stage due to the focus of the research questions.

Phases of Thematic Analysis (Table 3.3), set out a clear six step process that will allow for the outputs from each pilot/main study to be organised into key themes and data sets for easier analysis of findings, key themes as well as a comprehensive list (dissemination of findings), of the types of interactions, timings (asynchronous or synchronous), and objects suitable for both parents and children, within a family communication system.
These six steps of analysis, as detailed in Table 3.3, will be used across each of the smaller studies as well as the main study to keep the data and findings generated from each, consistent, unbiased, and easily accessible.

The six phases of thematic analysis were used throughout the small-scale and main study, to sort the data into specific codes and themes, see Chapter 4 Sections; 4.3, 4.4, 4.5, 4.6, 4.7, and Chapter 5, Section; 5.7 *Analysis*. This allowed for all information about the families, their communications, and specifications for preferred modes of communication and suitable communication objects to be clearly categorised for cross reference, future studies, and dissemination purposes.

Table 3.3 Phases of Thematic Analysis

PHASE	DESCRIPTION OF THE PROCESS
1. Familiarising yourself with your data:	Transcribing data (if necessary), reading and rereading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic "map" of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Table 3.3 Phases of Thematic Analysis, adapted from Braun and Clarke, 2006, p35.

3.4 Conclusion

This chapter has discussed the Participatory Action Research methodology used in this research, a qualitative form of applied research. It is research which brings together a group of people as 'co-researchers', affected by similar issues and lets them discuss what lies at the root of the problem, and together form a solution. A methodology such as this demystifies the research process to the community, in this case the families, because they are co-researchers in the project. This means that the participants become researchers (participant researchers) and the researchers become participants (researcher participants).

Learning is drawn from everyone's experiences and knowledge to create a solution to a problem that the families have defined.

Participatory Action Research is based on reflection, data collection, and action and seeks to understand and improve the problem collectively. The reflective process is directly linked to action. The process of Participatory Action Research aimed to be empowering for the families, especially the children, leading them to have increased control over their communications.

Participatory Action Research allowed for objectiveness throughout the research process, dispelling any personal thoughts and theories about the research topic from the researcher. This was achieved by listening to the participants and letting them drive the discussions and generate the content for analysis, whilst supporting each family member's viewpoint. Important themes and talking points were introduced during these discussions surrounding communication methods, objects, and preferred modes (i.e. synchronous communications), to ensure the agenda and design aims, objectives and questions (Chapter 1, Sections 1.2 *Research Questions*, and 1.3 *Aims and Objectives*) were being properly met and answered.

CHAPTER 4 Small-Scale Studies

4.1 Introduction

This chapter will take the reader through the five small-scale studies that were undertaken:

- ***Pigeon Post*** - Section 4.3
- ***Skyping Scarf*** - Section 4.4
- ***Message in a bottle*** - Section 4.5
- ***The KIST project*** - Section 4.6
- ***Smart networked toys*** - Section 4.7

It will give a brief overview of the studies, the rationale for each, and the data produced, summarising the key learning from each small-scale study and how this informed the Main Study (Chapter 5; *The Trace Project*).

Aim of the small-scale studies:

The key aim within each of the small-scale studies was aim 2 of the overall research:

> *'to explore the integration of intimacy, within family communication systems through play'*

By investigating this aim, we looked to answer the overall research questions:

> RQ1: *Can wearables and smart textiles aid intimacy within family communication systems?*
>
> RQ2: *What is the role of co-design in the understanding and creation of such a system?*

However, each study had its own nuanced research sub-question (see Table 4.1). This allowed for the research questions to evolve through the participatory nature of the methodology (see section 1.2.4 Shifting Research Questions).

Table 4.1 Small Scale Studies Research Questions

Study	*Research Question*
Pigeon Post	Can children have emotional resonance for portable objects when they connect them to family, events or interests online?
Skyping Scarf	Can children have emotional resonance for worn objects when they connect them to a parent through Skype?
Message in a bottle	Do handmade and physical objects offer higher levels of intimacy in family communication (from the families' perspectives), than telephone and Skype calls?
The KIST project	Can handmade objects, linked to online content enable affective intimacy in families with complex communication needs?
Smart networked toys	Can co-presence and commitment (a form of intimacy), be designed in family communication objects through the process of co-design?

Table 4.1 Small Scale Studies Research Questions

Family Recruitment:

Families were recruited for participation as follows:

- ***Through online promotion*** such as the researcher's blog, twitter and other social networking sites; capturing the researcher's online network.

- ***Through word of mouth and poster calls*** at the University of Dundee and Dundee and Angus college; capturing academics/students/support staff.
- ***Through previous connecti***ons from a time working in a children's nursery; capturing families from varied societal and economic backgrounds.

Participant Families:

Twenty different families (which included children ranging from three to twelve years old) were involved in the small-scale and main studies. The breakdown of participating families, is shown in Table 4.2.

Table 4.2 Participant families involved in the small-scale studies

	Number of Families	Number of Parents	Number of Children	Number of families who continued with research
Small-Scale Studies (totals)	**20**	**35**	**38**	**3**
1. Pigeon Post	5	12	10	1
2. Skyping Scarf	4	9	7	1
3. Message in a Bottle	6	8	12	2
4. KIST Project	6	12	9	0 *
5. Smart Network Toys	4	7	8	3

Table 4.2 Participant families involved in the small-scale studies

*No families continued into the Trace project from the KIST project as this small-scale study was undertaken at the Children's Hospice Association Scotland (CHAS), with children who

have life limiting conditions and complex communication needs. Therefore, through undertaking this pilot it became apparent that the children and families who visited CHAS had communication needs that required more specialised equipment and support than the Trace project could have offered (Parent and Staff discussion through KIST workshops, 2011-2013). The KIST project ran from 2011-2013 and developed into an online social network for sharing information and stories about the child's life, to their families, carers, and other professional bodies they have contact with such as school, clubs, and healthcare professionals.

Intimacy and Play:

Intimacy and play were two key aspects taken from the literature that this research explored. The literature suggested that intimacy could be achieved over distance through communication objects. This research explored if play held the capacity needed to create it.

Both *intimacy* and *play* were explored in each one of the five small-scale studies through the methods chosen (see table 4.3). Each small-scale study allowed the researcher to understand more about the individual families who took part, and how parent's needs differed from the needs of their children. They also explored how *play* could be used both within the creation of the communication objects (and systems), as well as in the types of communications the objects offered the families. Thus, play had a dual purpose when creating intimacy within the communication objects, through the physical making of the objects and later when using the objects to connect the families.

Intimacy:

As detailed in Chapter 2, section 2.5.1, several different types of intimacy were identified through the literature:

- ***Commitment*** - feeling of cohesion and connection.
- ***Affective intimacy*** - a deep sense of caring, compassion, and positive regard and the opportunities to express the same.

- ***Cognitive intimacy*** - thinking about and awareness of another, sharing values and goals.
- ***Physical intimacy*** - sharing physical encounters ranging from proximity to sexuality.
- ***Mutuality*** - a process of exchange or interdependence.

As physical intimacy is not possible (at the time of physical separation), for the families discussed in this research, it is not explicitly explored through the following five small-scale studies. However, through some of the making activities within workshops and generative toolkits as well as through de-briefing interviews, physical intimacy was observed (touching, laughing, eye contact) and captured through photography, as well as through the families' sayings doings and relating's.

Play:

Play was also identified through the literature as an important factor in relationship building (Chapter 2, section 2.5.2). Coming from Piaget's (1962) and Vygotsky (1976) theories on play, Lillard (2015 p428 -p433), outlines several different forms of play in childhood:

1. ***Exploratory Play***
2. ***Object Play***
3. ***Construction Play***
4. ***Physical Play*** - sensorimotor play, rough-and-tumble play
5. ***Dramatic Play*** - solitary pretence
6. ***Socio-Dramatic Play*** - pretence with peers, also called pretend play, fantasy play, make-believe, or symbolic play
7. ***Games with Rules*** - fixed, predetermined rules
8. ***Games with Invented Rules*** - rules that are modifiable by the players

Construction play and symbolic play (Socio-Dramatic Play), were deemed to have the best characteristics for use within a participatory action research methodology, due to their collaborative and imaginative nature, so were chosen as the main forms of play to explore through the small-scale studies.

Table 4.3 How play and intimacy were explored in the small-scale studies

Study	Method	Type of Intimacy Explored	Type of play explored
1 - Pigeon Post	User-experience testing	Mutuality	Symbolic Play
2 - Skyping Scarf	Co-design workshop / user experience testing	Cognitive intimacy	Symbolic Play
3 - Message in a Bottle	Interview guide / probe / diary study	Affective intimacy	Construction Play
4 – KIST Project	Generative toolkit / co-design workshop / informal conversational interviews	Affective intimacy	Construction Play
5 - Smart Networked Toys	Generative toolkit / co-design workshop	Commitment	Construction Play

Table 4.3 How play and intimacy were explored in the small-scale studies

4.2 Overview of Analysis

As reviewed in Chapter 3, thematic analysis was chosen to analyse data in this research, (see Chapter 3; *Methodology*, Section 3.1.2.1 *Thematic Analysis*). Thematic analysis was used to pinpoint specific types of communications that were important to the families throughout the small-scale studies, which helped to inform the main study and shape the subsequent methods used.

The following Table (4.4) shows what information was generated, along with how this data was categorised and analysed, uncovering the common themes through each of the small-scale studies. By categorising the data, it identified the main criteria for creating a family communication system.

The data was sorted showing participant families preferred types of communications and objects, suitable for use by both adult and children users. The data was to be captured and sorted into:

- What the data was and how it was collected.
- The types of communications sought; these were different due to the alternate needs parent and child have when communicating.
- The communication methods, modes and objects; suitable for both parent and child to meet their individual needs for communication.
- The communication objects; the aesthetics and interactions of both parent and child's communication objects within the family communication system.
- The key observations and quotes from the participant families supporting the categorisation of data (coding and themes), as well as the differences in parent/child communication needs (both emotional and practical), and how this information should be communicated (which modes and objects are best suited to each, parent and child).

The following sections will introduce and address the methods used for each study, its deployment, and data sets gathered.

Table 4.4 Phases of Thematic Analysis within the small-scale studies

Phase	Data	Methods
1. ***What is the data?***	Families sayings, doings and relating's (in relation to the small-scale studies)	Interview Guide / Informal Conversational Interviews Co-design workshops / Generative toolkits / Making Diaries
2. ***Coding the data***	Transcribing all of the families' sayings doings and relating's for analysis, resulting in a list of themes, codes and sub-codes.	Thematic Analysis (first stage coding)
3. ***Main themes identified***	- Understanding - Activities - Interaction - Reflection	Structural coding
4. ***Codes and themes***	Parent / Child communication methods, objects and synchrony	Thematic Analysis (second stage coding) Reviewing and checking themes 'work' in relation to raw data
5. ***Family Communication systems***	Finalising / refinement of themes, codes and sub-codes	Structural coding / Thematic Analysis
6. ***Families sayings***	Key quotes that support the themes and coded data sets	Thematic Analysis of the families' sayings

Table 4.4 Phases of Thematic Analysis within the small-scale studies, adapted from Braun and Clarke, 2006, p35.

4.3 Study 1; Pigeon Post

Research Question - *Can children have emotional resonance for portable objects when they connect them to family, events or interests online?*

Aim - *To explore the integration of intimacy, within family communication systems through play.*

Overview:

The Pigeon post study explored symbolic play. Plush toys and objects were created to symbolise family members. This looked to understand if mutuality, a form of intimacy, could be achieved by anchoring people to objects, through the object's design.

The Pigeon Post communication system offered children, aged three to eight years old, two main approaches of interaction. The first approach was to independently access online content such as YouTube and favorite webpages, e.g. Cbeebies (BBC, 2017), a children's television channel, and the second was to communicate with a loved one, through Skype (Microsoft, 2017), in a safe, secure manner using one or a series of tagged objects. This meant it could be used for one or two-way communications depending on the interactions the child wanted.

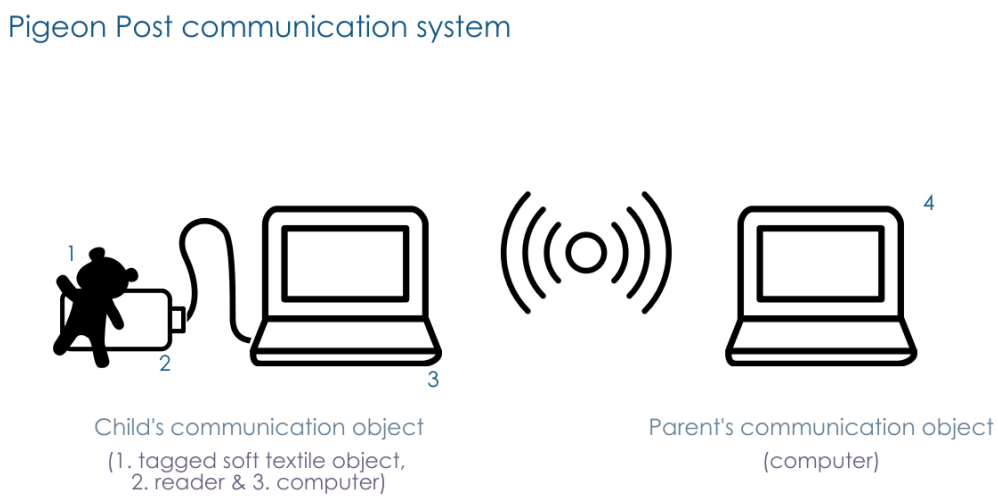

Figure 4.1 The Pigeon Post communication system

The Pigeon Post communication system (Figure 4.1) consisted of:

1. ***A child's toy*** - a digitally tagged soft textile object or series of objects.
2. ***A reader*** - to read the tagged objects.
3. ***A computer*** - which the reader was attached to and was the screen showing the interactions (YouTube video, Flicker photo stream, Skype call).
4. ***A second computer or Internet ready device*** - if a Skype call was being placed.

Pigeon Post allowed for the testing of new input methods (textile objects), meaning children could interact with the objects and not screens or keyboards as these can be problematic for young children to use.

Family Participants:

Table 4.5 Participant families involved in the Pigeon Post study

	Number of Parents	Number of Children	Children's ages	Continued with research
Family 1	2	1	4	No
Family 2	1	1	6	Yes
Family 3	3	2	3, 6	No
Family 4	2	3	4, 7, 8	No
Family 5	4	3	3, 4, 6	No

Table 4.5 Participant families involved in the Pigeon Post study

Methods:

Table 4.6 gives an overview of the data collection methods that were used at each key stage of the Pigeon Post study. For further details on the Pigeon Post study, including methods please see Appendix 3.2.

Table 4.6 The data collection methods that were used at each stage of Pigeon Post

When	What	Method
Start of Study	Introductory Interview	Interview Guide
Pigeon Post Iteration 1	Prototyping Conversational Interview	User testing Interview Guide / Informal Conversational Interviews
Pigeon Post Iteration 2	Prototyping Conversational Interview	User testing Interview Guide / Informal Conversational Interviews
Close of Project	Debriefing Interview	Interview Guide / Informal Conversational Interviews

Table 4.6 Data Collection methods used in Pigeon Post

Analysis

The families' sayings, doings and relating's were recorded through thematic analysis. Table 4.7 gives an overview of the categories, codes and sub codes that were identified through data analysis.

Table 4.7 Coding Scheme Pigeon Post

Categories	*Codes*	Sub-codes
Category 1 Understanding	Communications (should be/offer)	- Control for children - Easy to use / understand - Personalised Information - Non-screen based
	Current Communication Objects	- Mobile Phone / Landline (Audio) - Smart Phone / Tablet / Laptop using Skype (Audio and Visual)
Category 2 Activities	Engagement	- Personalisation - Appropriate - Easy to understand
Category 3 Interaction	Enabling connections	- Fun - Acceptance
Category 4 Reflection	Intimacy (achieved)	- Mutuality
	Positives	- Control for children - Easy to use / understand
	Negatives	- Personalisation (lack of)
	Suggestions	- More customisation / object choice - Non-screen based

Table 4.7 Coding scheme Pigeon Post

Four initial categories were formed, that related to each stage of the methodology (plan, act, observe and reflect), these were understanding, activities, interaction and reflection. By collecting the families' sayings, doings and relating's through user testing and informal conversational interviews, codes and sub-codes were created from the transcriptions of the raw data (table 4.7).

Summary:

Mutuality (a form of intimacy) was achieved through the pigeon post project by anchoring children to objects in the following ways:

> ***Control for Children*** - Allowed children to have control over communications. Children had the opportunity to choose, when they communicated and what type of communication they wanted to access through the personalised soft textile objects.

> ***Balanced Communications*** - Offered balance to communications. Children had a safe and easy to use system of communication, allowing them to engage in more balanced communications with their parents and family members; meaning they had equal opportunity for connection.

Figure 4.2 Child with Pigeon Post communication object (example)

Pigeon Post was a novel communication system, providing communication objects that could be used for both synchronous and asynchronous communications. It focussed on the children's needs, offering the child ownership and control of their communications through independently use of the communication system through RFID technology and handmade digitally tagged objects.

Through this project children built up connections to the hand-crafted objects. However, with the exception of the Skype call, children had no direct synchronous communication to their families. It was also determined that more choice was needed as to which communication was to be actioned.

It was discovered through the Pigeon Post study that more family engagement was needed within the early stages of the object design. They needed to be actively involved in the creation of the communication objects for the objects to offer sustainable communications. Whilst families enjoyed using the Pigeon Post system stating it was 'clever' (Parent 3) and 'really easy to use' (Parent 10), they wanted more control over the types of objects that could be tagged, or making their own objects, as then they would hold move value (sentimental) as well as offering them higher levels of intimacy when using the system.

Figure 4.3 The Pigeon Post communication system (example)

Key learning taken into the Trace project:

- ***Independent use*** - children needed a communication system that was easy and safe to use.
- ***More direct interaction with family*** – synchronous communication is needed.
- ***Object consideration*** - more input from families as to what the objects should look like, what communications they should offer, and how they can embody intimacy.

4.4 Study 2; Skyping Scarf

Research Question - *Can children have emotional resonance for worn objects when they connect them to a parent through Skype?*

Aim - *To explore the integration of intimacy, within family communication systems through play.*

Overview:

The Skyping scarf study explored symbolic play. Jersey tube scarves were created to symbolise family members. Fabric colours were chosen that appealed to the individuals and these were screen printed with favourite imagery, as reminders of family. This looked to understand if mutuality, a form of intimacy, could be achieved by anchoring people to objects, through the objects design. By giving families the opportunity to customise and personalise their scarves, would families feel more connected to one another when using these hand-crafted objects, that were made specifically for them. This built on the first small-scale study pigeon post, where families had little input in the design of the communication objects themselves.

The Skyping scarf communication system offered children independent access to Skype (Microsoft, 2017) a video calling platform. Children could 'Skype' a parent without having the knowledge, ability, or parental worry over safety concerns associated with this type of

online communication system.

The purpose of this study was to explore the wonder and delight of simple technology (Wallace and Press 2004, Wallace, 2007, Wallace, Dearden and Fisher, 2007 and Wallace 2014) via QR codes printed onto scarves, which children could scan, placing a Skype call to their parent. Would families feel more connected to one another using hand crafted objects, that were made specifically for them?

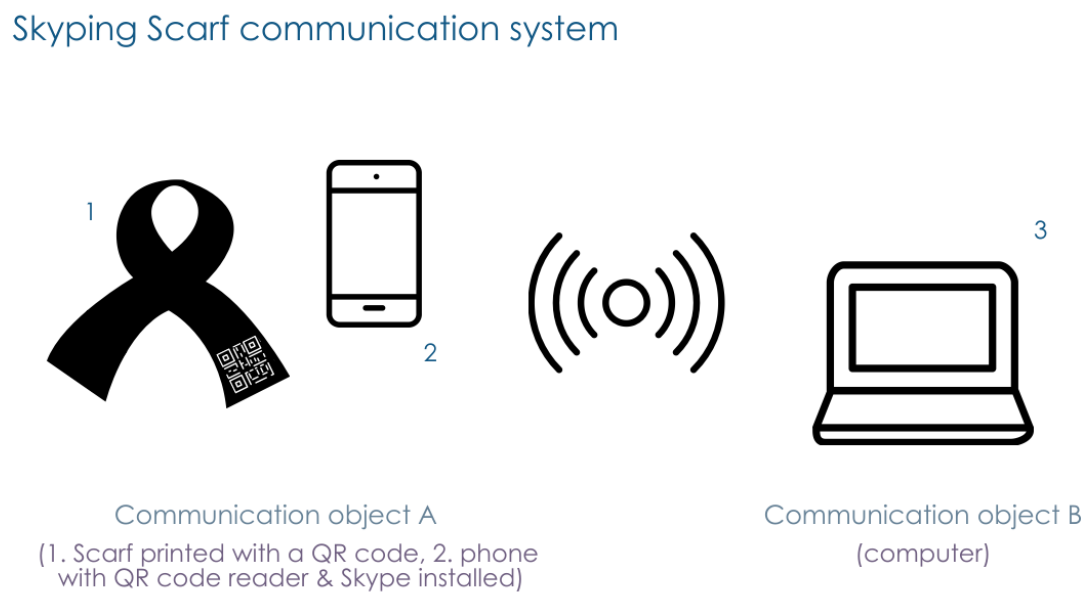

Figure 4.4 The Skyping Scarf communication system

The Skyping Scarf communication system (Figure 4.4) consisted of:

1. ***A scarf*** - printed with a QR code.
2. ***A phone*** - to read the QR code and view the Skype call.
3. ***A second computer or Internet ready device*** - for interaction (Skype call).

Family Participants:

Table 4.8 Participant families involved in the Skyping Scarf study

	Number of Parents	Number of Children	Children's ages	Continued with research
Family 1	1	1	6	Yes
Family 2	3	1	4	No
Family 3	4	2	4, 6	No
Family 4	1	3	3, 7, 9	No

Table 4.8 Participant families involved in the Skyping scarf study

Methods:

Table 4.9 The data collection methods that were used at each stage of the Skyping Scarf Study

When	What	Method
Start of Study	Introductory Interview	Interview Guide
Skyping Scarf Iteration 1	Prototyping Conversational Interview	User testing Interview Guide / Informal Conversational Interviews
Skyping Scarf Iteration 2	Prototyping Conversational Interview	User testing Interview Guide / Informal Conversational Interviews
Close of Project	Debriefing Interview	Interview Guide / Informal Conversational Interviews

Table 4.9 Data Collection methods used in the Skyping Scarf study

Table 4.9 gives an overview of the data collection methods that were used at each key stage of Skyping Scarf study. For further details on the Skyping Scarf study, including methods, please see Appendix 3.3.

Analysis:

Table 4.10 Coding Scheme Skyping Scarf

Categories	*Codes*	Sub-codes
Category 1 Understanding	Communications (should be/offer)	- Control for children - Easy to use / understand
	Current Communication Objects	- Non-screen based - Mobile Phone / Landline (Audio) - Smart Phone / Tablet / Laptop using Skype (Audio and Visual)
Category 2 Activities	Engagement	- Personalisation - Easy to understand
Category 3 Interaction	Enabling connections	- Fun - Acceptance
Category 4 Reflection	Intimacy (achieved)	- Cognitive intimacy
	Positives	- Control for children - Easy to use / understand
	Negatives	- Object (scarf) - Practicalities
	Suggestions	- Object choice

Table 4.10 Coding scheme Skyping Scarf

The families' sayings, doings and relating's were recorded through thematic analysis. Table 4.10 gives an overview of the categories, codes and sub codes that were identified through data analysis.

Four initial categories were formed, that related to each stage of the methodology (plan, act, observe and reflect), these were understanding, activities, interaction and reflection. By collecting the families' sayings, doings and relating's through user testing and informal conversational interviews, codes and sub-codes were created from the transcriptions of the raw data (table 4.10).

Figure 4.5 Skyping Scarf (example)

Summary:

Mutuality (a form of intimacy), was achieved by anchoring family members to objects, through the design of the scarves in the following ways:

> ***Balanced communications*** – both parent and child were given the same textile object (scarf) which they chose the imagery for. This allowed both parent and child to have equal control over their communications.

Personalised objects – the design of the scarves, using personal imagery, colours, and fabrics, as reminders of the family members, acted as constant reminders of the family bond held between parent and child even when not using for direct communication.

This meant that families felt more connected to one another using hand crafted objects, that were made specifically for them.

The Skyping scarf (Figure 4.5) was a unique communication system, providing wearable objects (scarves) that could be used for synchronous communications (Skype calls). It was very simple and easy to use, suggesting these would be viable features within intimate family communication systems. The children enjoyed the idea of independent communication, but used the scarf as a 'security blanket' and not a worn object. This suggested that objects (portable technologies) were preferable to worn objects (wearable technologies), thus, were a better option for children aged three to seven.

More personalisation was requested, with family participants favouring the 'snuggly' fabrics made from such as a parent's article of old clothing or favourite baby blanket. A varied selection of communications was also requested, as a Skype call (synchronous communication) was not always possible, desired or needed, due to the availability of the family participants, and the information or intimacy they required.

Barriers such as cost, safety issues, and children having continuous access to a system that included smart phones, tablets or home computers, resulted in the Skyping scarf being rejected as a viable family communication system.

Key learning taken into the Trace project:

- ***Independent use*** - children needed a communication system that was easy and safe to use.
- ***More direct interaction with family*** - synchronous
- ***Object consideration*** - more input as to what the objects should look like and what

communications they should offer.

- ***Multiple interactions needed*** - families require a range of communications to suit their varying needs throughout the day (i.e. availability for synchronous communications, information needed, and level of intimacy required).

4.5 Study 3; Message in a Bottle

Research Question - *Do handmade and physical objects offer higher levels of intimacy in family communication (from the families' perspectives), than telephone and Skype calls?*

Aim - *To explore the integration of intimacy, within family communication systems through play.*

Overview:

The Message in a Bottle study explored Construction Play. Families were giving probes (generative toolkits), including diaries, to explore play both when they were together and when they were apart. This was to determine if construction play could be used to create intimacy, specifically affective intimacy, through the making and play activities within the probe pack.

The message in a bottle study, began with a series of family interviews (parental only), which led to a series of five design probes (Gaver, Dunne and Pacenti, 1999) being personally created for deployment with the participant families. The probes aimed to discover the modes and systems 21st Century families used in their everyday communications. Alternate modes of communications were explored and identified by allowing families to consider their communications in new ways using simple games, objects, and making activities (found within the probe pack, Figure 4.6).

Figure 4.6 Message in a Bottle probe pack and contents

The Message in a Bottle Probe pack (Figure 4.6) consisted of:

- ***A welcoming message*** - including a list of instructions and the researcher's contact details in case any problems occurred.
- ***A diary*** - to record all thoughts, feelings. Participants were encouraged to use their diary as a scrapbook, and to put in any photographs, drawings, stories, feelings they felt important.
- ***A book of emotion stickers*** - to stick in their diaries showing how they felt during each diary entry.
- ***A pen*** - to use with the diary.
- ***A blank postcard, a stamp, and a blank envelope*** - to send to each other when apart.
- ***A pack of materials*** - such as glue, pens, scissors, foam, coloured card, buttons, ribbon, to use within the making activities.
- ***A set of blank Russian dolls*** - for personalisation and leaving messages/small gifts inside when apart.
- ***A task sheet, instructions, and a communication wheel*** - for communication and play activities.

Family Participants:

Table 4.11 Participant families involved in the Message in a Bottle study

	Number of Parents	Number of Children	Children's ages	Continued with research
Family 1	1	1	6	Yes
Family 2	2	2	4, 8	No
Family 3	1	2	4, 6	No
Family 4	2	2	5, 7	No
Family 5	1	3	3, 4, 9	Yes
Family 6	1	2	4, 6	No

Table 4.11 Participant families involved in the Message in a Bottle study

Methods:

Table 4.12 gives an overview of the data collection methods that were used at each key stage of the methodology (Participatory Action Research) during the Message in a Bottle study.

The probes method was based on the idea of information probes detailed in the Interliving project (Hemmings *et al*. 2002). The Message in a Bottle probes required participants to use alternate modes of daily family communication, such as postcards, made memory objects, hidden notes, and treasure hunts (rather than solely relying on telephone and Skype).

For further details on the Message in a Bottle study, including methods, please see Appendix 3.4.

Table 4.12 The data collection methods that were used at each stage of the Message in a Bottle Study

When	What	Method
Start of Study	Introductory Interview	Interview Guide
Message in a Bottle Pilot	Prototyping Testing different communication methods Conversational Interview	Design probe Generative toolkits Diary Study User testing Interview Guide / Informal Conversational Interviews
Message in a Bottle Deployment	Prototyping Testing different communication methods Conversational Interview	Design probe Generative toolkits Diary Study User testing Interview Guide / Informal Conversational Interviews
Close of Project	Debriefing Interview	Interview Guide / Informal Conversational Interviews

Table 4.12 Data Collection methods used in the Message in a Bottle study

Analysis:

The families' sayings, doings and relating's were recorded through thematic analysis. Table 4.13 gives an overview of the categories, codes and sub codes that were identified through data analysis.

Table 4.13 Coding Scheme Message in a Bottle

Categories	*Codes*	Sub-codes
Category 1 Understanding	Communications (should be/offer)	- Control for children - Easy to use / understand - Personalised Information - Non-screen based
	Current Communication Objects	- Mobile Phone / Landline (Audio) - Smart Phone / Tablet / Laptop using Skype (Audio and Visual)
Category 2 Activities	Engagement	- Personalisation - Appropriate - Easy to understand
Category 3 Interaction	Enabling connections	- Fun - Acceptance
Category 4 Reflection	Intimacy (achieved)	- Affective intimacy
	Positives	- Control for children - Fun
	Negatives	- Communication / object choice - Time
	Suggestions	- Synchronicity of communications - Non-screen based

Table 4.13 Coding scheme Message in a Bottle

Four initial categories were formed, that related to each stage of the methodology (plan, act, observe and reflect), these were understanding, activities, interaction and reflection. By collecting the families' sayings, doings and relating's through user testing and informal conversational interviews, codes and sub-codes were created from the transcriptions of the raw data (table 4.13).

Summary:

Construction Play was shown throughout the Message in a Bottle Study as a way to create intimacy, specifically affective intimacy, through the making and play activities within the probe packs in the following way:

> ***Caring and compassion*** – through activities such as the Russian dolls, allowing both parents and children to leave messages or small gifts for one another (see Appendix 3.4 for more information).

The children enjoyed participating in the activities (both when they were together or apart) while it helped the parents to become more mindful of how they communicate with their children when they are apart. With one father talking about leaving a note for his daughter to find in the morning as he was leaving very early for a business trip "*I wrote a little note the night before as I was away to Ayr very early, so she could see it in the morning. I put it in her Russian Doll. It was a simple note just saying, I love you, eat all your breakfast and listen to mummy. I wish I did more things like this*".

The results from this initial study formed the basis for developing new methods of emotive communications within a soft textile context. Building upon the previous pilot studies and affirming that the most viable features for an emotive communication system for parent and child would be a soft two-way communication system.

The Message in a Bottle Study was created to gain insight into the communication technologies that 21st Century families currently use. The family participants started to

question these current technologies for creating intimacy in family communications through the making activities, games, and objects found within the probe packs. The participant parents started to reflect upon their current communications (through their diaries and discussions in follow-up interviews). This reflection enabled them to consider possible adjustments that could be made, within their current communications, helping their children understand their separation and to achieve higher levels of intimacy when apart.

The Message in a Bottle design probe proved to be an essential exercise in understanding what methods and modes of communication could be used to engage the family participants in the design process. Through discussion, diary entries and the act of making objects, it was found that a co-design practice would be a viable option for creating personalised communication objects to be used within family communication systems to foster intimacy whilst apart.

Key learning taken into the Trace project:

- ***Methods***- making activities to generate ideas but also to aid discussion and development of families' ideas.
- ***Play*** - fun and games should be part of the interactions within the family communication system.
- ***Personalisation*** - customisation to give added value to the objects (mediated intimacy through co-presence).
- ***Object consideration*** - what should the objects be, and should they have working technology enabling synchronous communications?
- ***Multiple interactions needed*** - families require a range of communications to suit their varying needs throughout the day (i.e. availability for synchronous communications, information needed, and level of intimacy required).

4.6 Study 4; KIST Project

Research Question - *Can handmade objects, linked to online content enable affective intimacy in families with complex communication needs?*

Aim - *To explore the integration of intimacy, within family communication systems through play.*

Overview:

KIST is a one-way soft communication system that allowed children to share information about themselves through 'gifting' co-designed objects to family or carers (Figure 4.7). Information was shared by digitally tagging handmade objects to online information about the child, such as favourite, stories, videos, music or places. The communication objects, which were soft textile pincushions gave insights into the children's individual personalities, likes, dislikes, and history.

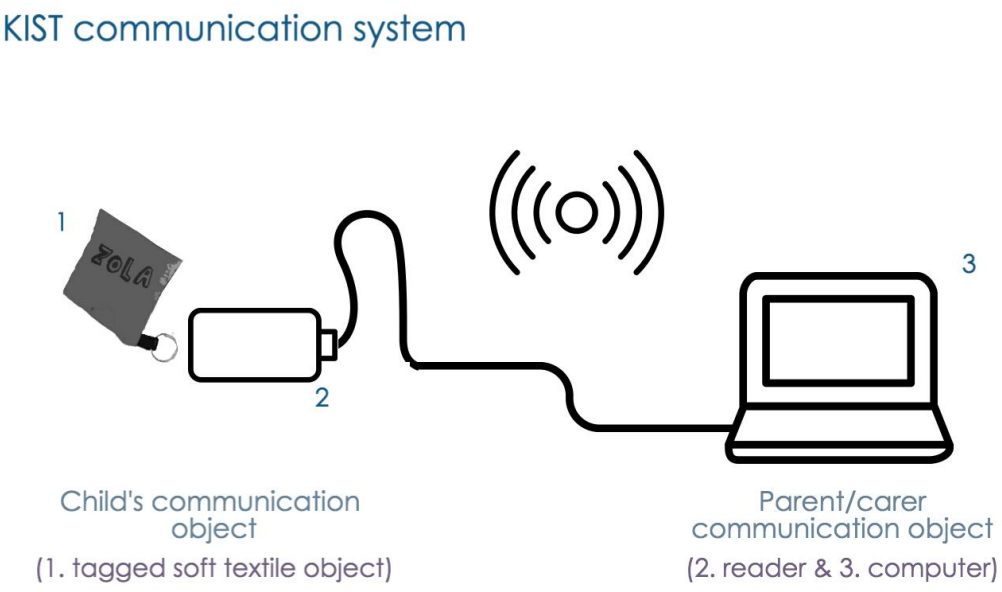

Figure 4.7 The KIST communication system

The KIST communication system (Figure 4.7) consisted of:

- ***A handcrafted pin cushion*** - a digitally tagged soft textile object or series of objects.
- ***A reader*** - to read the tagged objects.
- ***A computer*** - which the reader was attached to and was the screen showing the interactions (YouTube video, Flicker photo stream, personal website).

Family Participants:

The KIST project was undertaken with children at the Children's Hospice Association Scotland (CHAS) who had complex communication needs and life limiting conditions. KIST offered the children some control over their personal information and their communications, in being able to choose whom they shared these with.

Table 4.14 Participant families involved in the KIST study

	Number of Parents	Number of Children	Children's ages	Continued with research
Family 1	2	1	7	No
Family 2	2	2	6, 9	No
Family 3	2	2	7, 12	No
Family 4	2	1	8	No
Family 5	2	2	4, 8	No
Family 6	2	1	7	No

Table 4.14 Participant families involved in the KIST study

Recruitment for the KIST project was different to the other studies and was dependant on the families that were present in the hospice on the day of the workshops, along with their willingness to take part in the workshops.

Methods:

Table 4.15 gives an overview of the data collection methods that were used at each key stage of the KIST project. For further details about the KIST project, including methods please see Appendix 3.5.

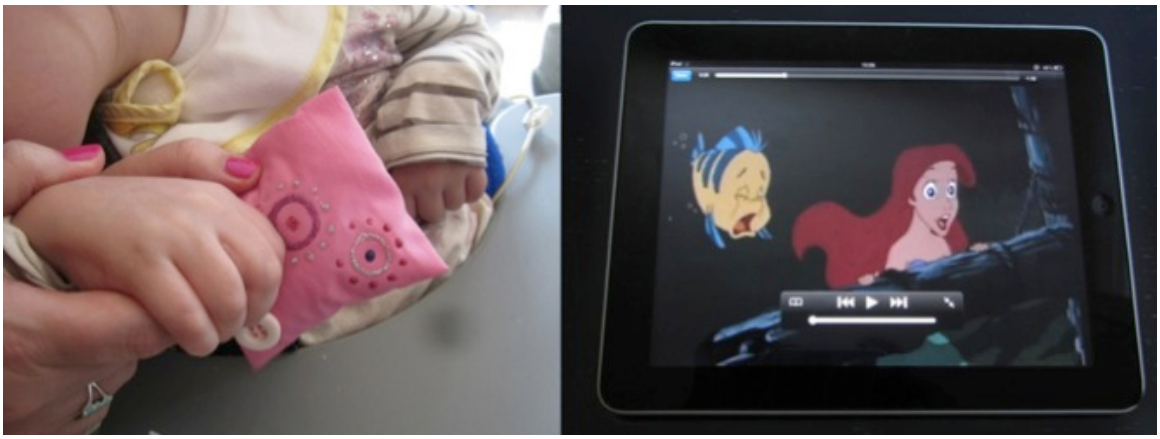

Figure 4.8 Pincushion connecting to online content (example)

Table 4.15 The data collection methods that were used at each stage of the KIST Project

When	What	Method
Start of Study	Introductory Interview with CHAS (Staff, cares and parents)	Interview Guide
KIST Project Co-design workshop 1	Prototyping Testing different communication methods Conversational Interview	Generative toolkits User testing Interview Guide / Informal Conversational Interviews
KIST Project Co-design workshop 2	Prototyping Testing different communication methods Conversational Interview	Generative toolkits User testing Interview Guide / Informal Conversational Interviews
Close of Project	Discussion	Interview Guide / Informal Conversational Interviews

Table 4.15 Data Collection methods used in the KIST Project

Analysis:

The families' sayings, doings and relating's were recorded through thematic analysis. Four initial categories were formed, that related to each stage of the methodology (plan, act, observe and reflect), these were understanding, activities, interaction and reflection. By collecting the families' sayings, doings and relating's through user testing and informal conversational interviews, codes and sub-codes were created from the transcriptions of the raw data (table 4.16).

Table 4.16 Coding Scheme KIST Project

Categories	*Codes*	Sub-codes
Category 1 Understanding	Communications (should be/offer)	- Control for children - Easy to use / understand - Personalised Information
	Current Communication Objects	- Mobile Phone / Landline (Audio) - Smart Phone / Tablet / Laptop using Skype (Audio and Visual - Written notes / diaries
Category 2 Activities	Engagement	- Personalisation - Appropriate - Easy to understand and use
Category 3 Interaction	Enabling connections	- Fun - Acceptance - Control
Category 4 Reflection	Intimacy (achieved)	- Affective intimacy
	Positives	- Control for children - Fun
	Negatives	- Workshops setting (how can this be re-created at home)
	Suggestions	- Platform for updating objects / information

Table 4.16 Coding scheme KIST Project

Summary:

The KIST project gave families and carers of children with complex communication needs a novel one-way soft communication system that offered asynchronous communications. It aided family members and carers to better understand and communicate with the children, whilst appreciating important aspects of the child's personality through the tagged objects.

Key learning taken into the Trace project:

- ***Methods*** - making activities to generate ideas but also to aid discussion and development of families' ideas.
- ***Independent use*** - children needed a communication system that was easy and safe to use.
- ***More direct interaction with family*** - synchronous
- ***Object consideration*** - more input as to what the objects should look like and what communications they should offer.
- ***Multiple interactions needed*** - families require a range of communications to suit their varying needs throughout the day (i.e. availability for synchronous communications, information needed, and level of intimacy required).

4.7 Study 5; Smart Networked Toys

Aims and Objectives:

Research Question - *Can co-presence and commitment (a form of intimacy), be designed in family communication objects through the process of co-design?*

Aim - *To explore the integration of intimacy, within family communication systems through play.*

Overview:

The Smart Networked Toy study explored construction play. It resulted in a series of toys

made through co-design workshops with no working technology (Figure 4.9). The study looked to understand if commitment (a form of intimacy) could be achieved through collective making. The toys were concept prototypes made from the children's drawings of their parents, which were used as props within the participant families. The toys were talking points to help participant families imagine ideal functionality and aesthetics of a family communication system, as an alternative to screen-based communication systems. They allowed ideas and discussion to flow due to their neutral nature (no functioning technology), meaning they were open to interpretation, allowing for a 'dreaming' and 'blue sky thinking' phase during the process. This process of idea elaboration enabled the families to project their ideas, wants, and needs for a family communication system onto the toy, being free to imagine ideal solutions and not being confined to their understanding of current communication devices and their corresponding capabilities.

Family Participants:

Table 4.17 Participant families involved in the Smart Networked Toys study

	Number of Parents	Number of Children	Children's ages	Continued with research
Family 1	1	1	6	Yes
Family 2	2	3	3, 4, 9	Yes
Family 3	2	2	3, 6	Yes
Family 4	2	2		No

Table 4.17 Participant families involved in the Smart Networked Toys study

Methods:

Table 4.18 gives an overview of the data collection methods that were used at each key stage of the Smart Networked Toys study. For further details on the Smart Networked Toys

study, including methods, please see Appendix 3.6.

Table 4.18 The data collection methods that were used at each stage of the Smart Networked Toys Study

When	What	Method
Start of Study	Introductory Interview with parents	Interview Guide
Smart Networked Toys Co-design workshop 1	Prototyping Testing different objects/materials Conversational Interview	Generative toolkits User testing Interview Guide / Informal Conversational Interviews
Smart Networked Toys Co-design workshop 2	Prototyping Testing different objects/materials Conversational Interview	Generative toolkits User testing Interview Guide / Informal Conversational Interviews
Close of Project	Discussion	Interview Guide / Informal Conversational Interviews

Table 4.18 Data Collection methods used in the Smart Networked Toys Study

Analysis:

The families' sayings, doings and relating's were recorded through thematic analysis. Four initial categories were formed, that related to each stage of the methodology (plan, act, observe and reflect), these were understanding, activities, interaction and reflection. By collecting the families' sayings, doings and relating's through user testing and informal conversational interviews, codes and sub-codes were created from the transcriptions of the raw data (table 4.19).

Table 4.19 Coding Scheme Smart Networked Toys

Categories	*Codes*	Sub-codes
Category 1 Understanding	Communications (should be/offer)	- Control for children - Easy to use / understand - Personalised Information - Non-screen based
	Current Communication Objects	- Mobile Phone / Landline (Audio) - Smart Phone / Tablet / Laptop using Skype (Audio and Visual)
Category 2 Activities	Engagement	- Personalisation - Appropriate - Easy to understand
Category 3 Interaction	Enabling connections	- Fun - Acceptance
Category 4 Reflection	Intimacy (achieved)	- Commitment
	Positives	- Appropriate objects (for children) - Easy to understand
	Negatives	- No working technology to test
	Suggestions	- More customisation / object choice

Table 4.19 Coding scheme Smart Networked Toys

Summary:

The Smart Networked Toys study was used to determine where co-design methods would be best utilised, and which modes of communications and communication objects would be most suitable for an intimate parent and child communication system.

It was found that intimacy could be achieved (specifically commitment) by allowing the families to become more actively involved in the co-design process, through the physical making experience. This process anchored the families to their objects as well as each other due to the sentimental value held within the made object through the family experience of collaborative making.

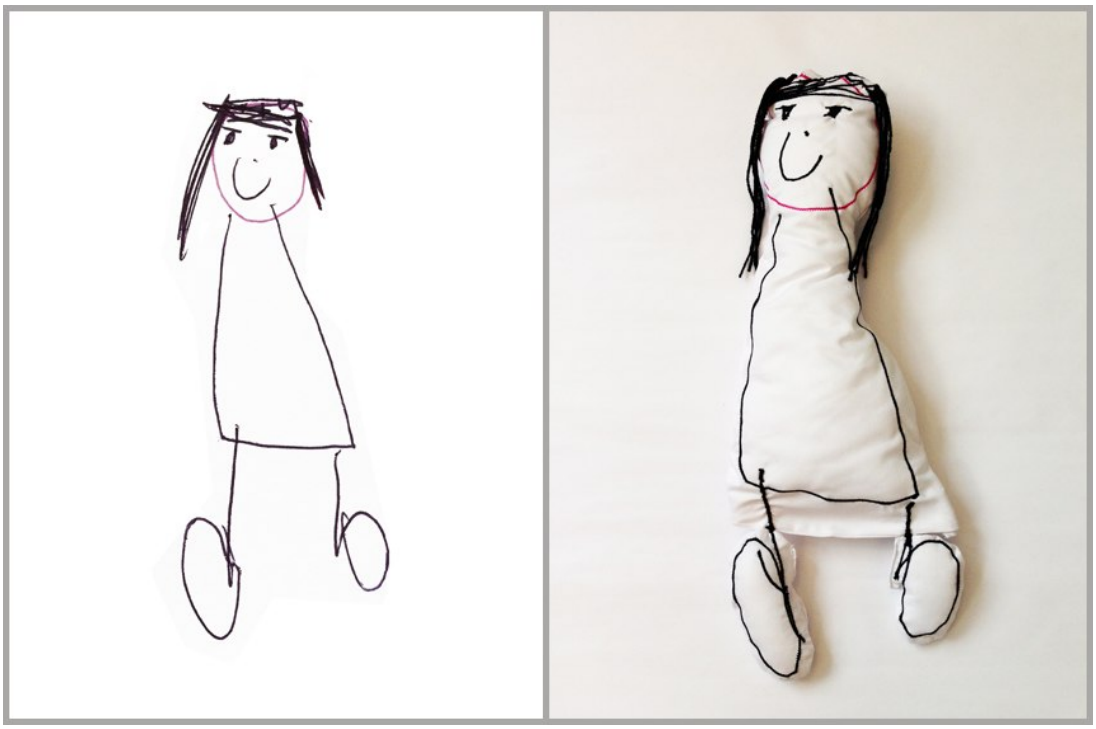

Figure 4.9 Example Toy from the Smart Networked Toys Study

Key learning taken into the Trace project:

- ***Independent use*** - children needed a communication system that was easy and safe to use.

- ***Methods*** - making activities to generate ideas but also to aid discussion and development of families' ideas.
- ***Play*** - fun and games should be part of the interactions within the family communication system.
- ***Personalisation*** - customisation to give added value to the objects (mediated intimacy through co-presence)
- ***Object consideration*** - what should the objects be, and should they have working technology enabling synchronous communications?
- ***Multiple interactions needed*** - families require a range of communications to suit their varying needs throughout the day (i.e. availability for synchronous communications, information needed, and level of intimacy required).

4.8 Summary of the Small-Scale Studies

These five small-scale studies offered insights into the reasoning's behind the chosen methods, how information was collected, and how the small-scale studies allowed for trust to be built between the researcher and the families who took part.

The small-scale studies offered insight into which methods were suitable and appropriate for use with families, to generate the desired knowledge for the main study. They offered understanding into ethical procedures when working with young children, as well as building empathy and understanding of the families and their separation issues.

Recruitment was a fluid process; three of the families that took part in one or more of the pilot studies continued into the main study. This resulted in the researcher working sporadically with the families for three to five years, building a good working relationship with the families, which included familiarity and trust. This allowed the families to feel relaxed when the researcher was present, which resulted in truer accounts of events through open and honest conversations.

Over the course of the five small-scale studies, 20 families took part, consisting of 41 adults and 36 children. 3 out of these 20 families continued to be co-designers in the main study,

the Trace Project (Chapter 5).

The small-scale studies used methods such as co-design, prototyping, workshops, interviews, and discussions, to understand how we might usefully integrate 'the Internet of Things' into our lives. Through each study suggestions of suitable modes for family communication were made. These suggestions aligned with the contextual review that was conducted at the start of the research and suggest that modes of communication that are the most valuable in terms of creating or projecting the feeling of intimacy over distance would be through a soft two-way communication system. The small-scale studies have offered further evidence to further the opinion that offering both parent and child the same communication object within the communication system would not offer the best results in terms of intimate communication (Druin, 2009). This is due to likelihood of acceptance and use that the communication objects may trigger if they are not designed to fit into each user's life. It has been shown that parent and child have very different communication needs in terms intimate connectedness when apart. To be successful, communication objects must take into consideration each individual's unique set of needs, wants, and desires and be tailored accordingly. This can be achieved through a co-design method, ensuring both parent and child are included in the design of the communication objects and systems.

The small-scale studies offered a deeper knowledge base and understanding of remote communication within family relationships (parent and child), highlighting where the gaps in knowledge were. They affirmed what was learned through the literature review concerning relevant modes of communication for use within parent and child relationships. Family communication systems should offer disparate objects that had both synchronous and asynchronous communication capabilities.

The scoping and pilot studies were also key within the recruitment process for the families who later took part in the main study the Trace project. All the families who took part in the Trace project had been involved with at least one of the pilot studies. These early studies allowed for a deeper understanding and empathy for the separations that the participant families faced daily, and identified which modes were the most suitable for the parent and children for remote communications.

In summary, the small-scale studies:

1. Highlighted the importance of the 'physical object' whilst explaining an idea.
2. Highlighted the technical problems that could occur if the technology is not right.
3. Showed the importance of user engagement with prototypes and how suggestions for different contexts for use could be gained from the general public and peers by attending events and exhibiting work.
4. Re-iterated the importance of 'trust' in a device/object, and the fear of the unknown.
5. Focused the research, detailing the key factors that communications should offer when prototyping and how they would be conceived.
6. Supported the need for disparate communication objects in communication systems for use within families for parent and child remote intimate communication.
7. Highlighted the importance of real time communications (synchronous in time) while understanding that this is not always possible due to work/school/travel commitments. Therefore, expanding this understanding to consider asynchronous timings of communications, and what could be offered in terms of instant feedback for users, so they do not feel rejected when their communications are not reciprocated immediately.

The small-scale studies were integral to the recruitment of the three participant families who took part in the main study, the Trace project (Chapter 5). Technologies were also explored that would be suitable for use in the main study's communication systems and affirmed the need for disparate objects with synchronous and asynchronous communications in novel soft two-way portable communication objects.

5.1 Introduction to the Trace Project

The Trace Communication System (Figure 5.1) was the final output of the Trace Project. It consists of a plush toy (the child's communication object) paired with a bespoke smartphone application (the parent's communication object). The Trace Communication System uses user-generated content enabling families to stay intimately connected whilst apart.

As established earlier in this thesis, a deeper connection can be created via personalised, empathetic communication objects when co-designed by users.

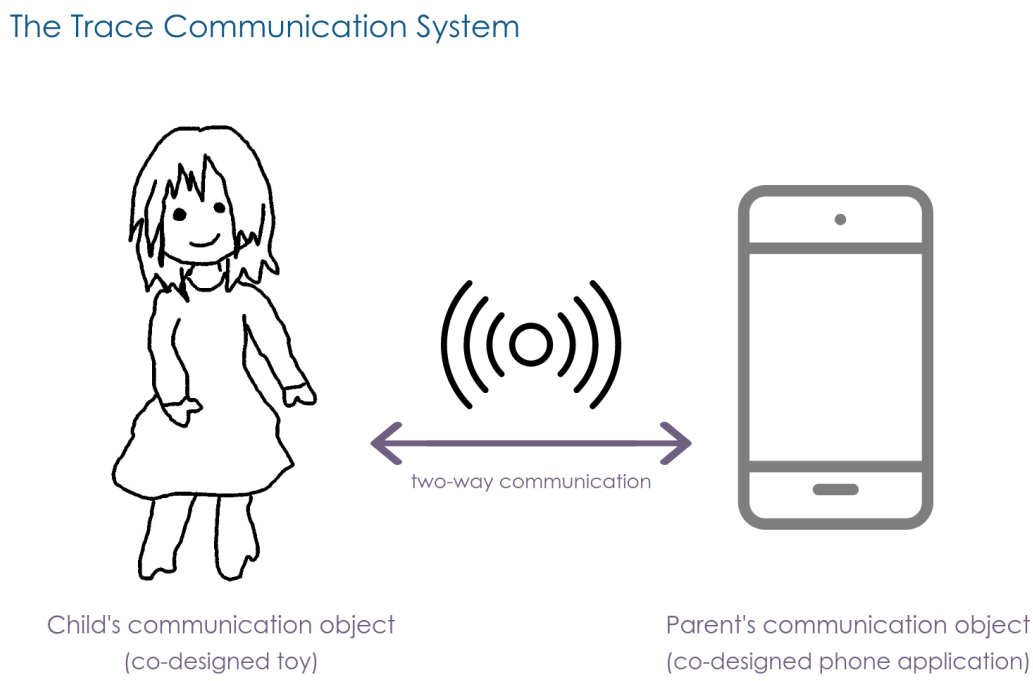

Figure 5.1 The Trace Communication System

Play is central to children's learning and the formation of relationships; thus, toys were used as the child's communication object in the Trace Communication System. The children's communication objects (plush toys) were designed to allow the children to self-select communications depending on the level of intimacy required in the moment of communication. This allowed the children more control over their emotional needs through their selection(s). Communications with parents were activated by children, through interactions and play with their toy. Feedback regarding the child's interaction was sent directly to the parent's app, as well as being stored on a central server, offering a historical log of interactions which were used for later analysis (see Sections 5.6, 5.7 and Appendix 4.6) of how and when the toy was played with (using information about what communication was sent and at what time, respectively).

Plush toys (soft textiles) were chosen for the children's communication objects because of their sensory appeal and the resonance and comfort they can offer children as 'security objects' (Stevenson, and Winnicott, 1954; Litt, 1981; Lehman *et al*. 1992). When these are self-made, they hold meaningful connotations for the people who have made them or have had them made for them (Wallace *et al*. 2007; Wright, Wallace and McCarthy, 2008; Kettley *et al*. 2015). Thus, a co-designed plush toy would be a more welcome and fitting child's communication object than screen-based technologies such as tablets or smartphones.

Using this system parents had the ability to send a communication from their app directly to their child's toy. The communication objects' characteristics (i.e., the look, size, shape, material, usability), the interactions they produced (synchronous, asynchronous, types of communications), along with the tracing and storing of data (location sensing technology), were all designed using direct feedback from the families involved. These design functions and features were derived from the families' 'sayings', 'doings' and 'relatings' of what a family communication system needed to offer them, as a family, to meet their emotional needs whilst apart, whilst giving them easy-to-use objects that could be integrated effortlessly into family life.

Research Aims, Objectives and Research Questions:

Main Research Questions:

RQ1: Can wearables and smart textiles aid intimacy within family communication systems?

RQ2: What is the role of co-design in the understanding and creation of such a system?

Aims:

1. To explore the potential of wearable technologies and smart textiles within family communication systems.

2. To explore the integration of intimacy, within family communication systems through play.

3. To explore the potential of disparate but connected communication objects within family communication systems.

Objectives:

1. To facilitate intimacy within family communication systems through a co-design approach.

2. To identify suitable methodologies and methods to be used within family research. (a participatory design methodology, using the say, do, make model)

3. To develop recommendations for communication modes and objects within family communication systems that will offer intimacy for the families who use them.

The main study of this research, the Trace Project, like the small-scale studies, explored a set of nuanced research questions specific to the study that fed into the main research questions, aims and objectives of the overall research. These were as follows:

Trace Project specific Research Questions:

RQ1: What is the value of disparate communication objects in family communication systems when creating intimacy?

RQ2: Are asynchronous or synchronous communications more suitable for family communication systems?

RQ3: Is the say, do make model a suitable method for co-designing a family communication system?

5.2 The Families (Co-designers) of the Trace Communication System

The Trace Project was undertaken with three separate families, consisting in total of seven adults and six children, of which four adults and all six children took part (Figure 5.2).

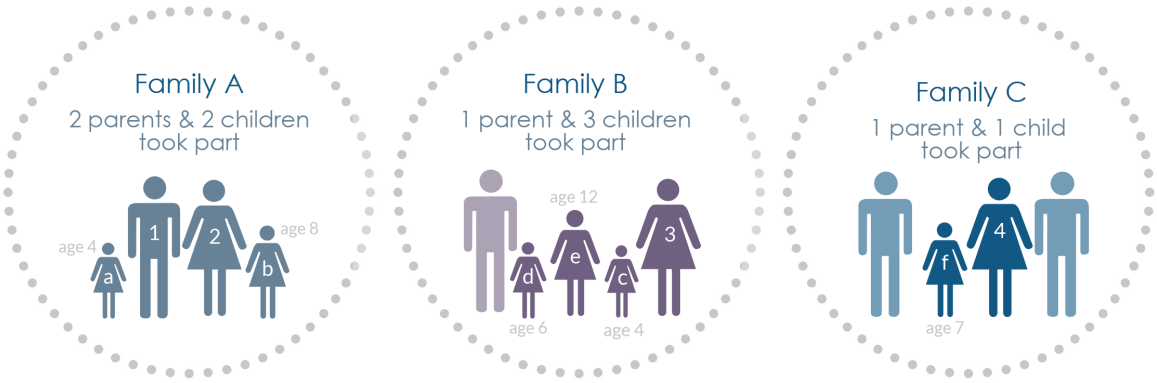

Figure 5.2 The composition of the three families who took part in the Trace Project

Family A consisted of two parents and two children (aged four and eight) who were separated by work commitments. All family members were involved in the

research.

Family B consisted of two parents and three children (aged four, six and twelve) who were separated by child illness. All three children and the mother took part in the research.

Family C consisted of three parents (two biological and one step-parent) and one child (aged seven) who were separated by parental relationship breakdown. The child and mother took part in the research.

The researcher worked with the families at each key stage of the participatory action design process (plan, act, observe and reflect), co-designing the Trace Communication System with them. This ensured that all the features, the look, the feel and the usability, of the Trace Communication System, were in line with what the families wanted.

5.3 Funding

£7,483 of external funding was secured from New Media Scotland's Alt-W Fund (funded by the Centre for Design Informatics, Creative Scotland and the Scottish Government) to undertake the main study entitled 'The Trace Project'. The funding and application process can be found in Appendix 4.1, New Media Scotland Alt-W Fund *Application* (Appendix 4.1.1) and *Report* (Appendix 4.1.2).

The funding was vital to the Trace Project, which ran from July 2013 until April 2014, as it allowed the researcher to build a multidisciplinary team (consisting of a programmer/app developer, two artist/illustrators, an engineer, and a textile designer) to support the creation of the communication objects that the families envisaged. Without receiving these external funds, access to the skills needed to create the families' design ideas and have fully working prototypes (of the Trace Communication System) for testing would not have been possible.

5.3.1 Trace Multidisciplinary Project Team (at the time of the research)

The project team who worked on the Trace Project were as follows:

> ***Programmer/App Developer of the Trace App:*** **Alan Clelland**, who is a Lead Server Engineer at Ninja Kiwi, with a background in computer programming and app development, having worked with several notable games companies in Dundee, such as Outplay Ltd, Tag Games, and Dynamo Games.
>
> ***Artist/Illustrator of the Trace App:*** **Graham Galvin**, who is the Art Manager and Lead Artist at Outplay Entertainment Ltd, with a background as a Digital Artist working for companies such as Zoonami, Denki and Dynamo Games.
>
> ***Artist/Illustrator of the Trace Book and Diary:*** **James Law**, who is the Art Director at Sixteen South, with a background in animation and digital artwork, and who has worked with companies such as Outplay Ltd, Denki, and Cohort Studios Ltd.
> ***Engineer of the Trace Toys Hardware:*** **Chris Martin**, who is a Researcher in Applied Computing at the University of Dundee, with a background in HCI, interaction design and user experience.
>
> ***Textile Designer, Responsible for Part of the Construction of the Trace Toys:*** **Selina Law**, who is a freelance Service Designer with a background in constructed textile design, lecturing in textile design and primary school teaching.

5.4 Process

The Participatory Action Research Methodology allowed the data that was gathered to be analysed, reflected upon and developed at each of the five stages within the Trace project. This gave for a greater understanding of the families within the Trace project, and allowed for continuous iteration, of the problem through each of the co-design workshops, through user-testing and finally through reflection.

Methods were chosen for the main study, based on the results and key learning from the

small-scale studies. These determined the suitability and viability of the methods to generate the desired information and participation from participant families for co-designing the Trace Family Communication System.

A Qualitative Approach to Designing a Family Communication System:

The gathering and analysis of the Trace project raw data consisted of series of empirical methods as follows:

- Semi structured *introductory interviews* (using the Interview Guide style) were conducted at the start of the project for information gathering.

- *Co-design workshops* were used to enable the families to have input on the look, feel, size, and interactions the communication systems would have using Sanders (1999), *say do, make model*. These included *Interview Guide* and *Informal Conversational Interviews.*

- *User testing* allowed the families to test the communication systems determining the value of tailored, co-designed family communication systems within the design of family communication systems.

- *Diary studies* (part of the user testing) allowed for the reporting of initial thoughts and feelings about using the communication system.

- Semi structured *debriefing interviews* (using the Interview Guide and Informal Conversational Interviews styles) were conducted at the end of the project for validation of findings and debriefing purposes. The questions here were tailored to each individual family's responses (diary studies) and interactions with the Trace communication system.

There were four phases within the Trace Project that produced the four initial categories for analysis and these were Understanding, Activities, Interaction and Reflection, as shown in Table 5.1.

Table 5.1 Phases of the Trace Project

PHASE	*CATEGORY*	*ACTION*	*METHOD(S)*	*RATIONALE*
1	Understanding	Introductory Interview	Interview Guide	Used as a method to understand the families and their communication needs as well as to inform the co-design workshops.
2	Activities	Co-design Workshop (1 & 2) Interview(s)	Say, Do Make Model; Generative Toolkit: worksheets, drawing, making Interview Guide / Informal Conversational Interviews	Used to inform the design of the Trace Communication System.
3	Interaction	User-testing	User-experience testing Diary studies	The Diary studies and the de-briefing interviews were used to verify the interaction data collected through user testing.
4	Reflection	De-briefing Interviews	Interview Guide / Informal Conversational Interviews	

Table 5.1 Phases of the Trace Project

The Trace Project was also sectioned into two parts. The first part captures phase one and two (Understanding and Activities), see Figure 5.3. This section looked at the co-design of a family communication system, the Trace Communication System. The main methods used

here were interviews (both interview guide and conversational interviews), and prototyping, using generative toolkits, through the co-design workshops.

The second part, combines category three and four (Interaction and Reflection), this part looks at the user-testing and reflection of the Trace Communication System. The families sayings, doings and relatings were captured through the interaction data (from the user testing of the system), diary studies (capturing immediate reactions to using the system) and de-briefing interviews (reflecting back on the system). These multiple methods captured how, why and when the families used the Trace communication system, their immediate responses to using the system and a later reflection on the system. The de-briefing interviews were important as it allowed the families to comment upon the design and testing of the system as well as the suitability of it as a family communication system (see appendix 4.10.6).

Figure 5.3 gives an overview of the methods used throughout each stage of the main study. It is sectioned into four main phases, which follows a Participatory Action Research Methodology. Within each phase there are one or more iterations of the action research cycle (planning, acting, observing and reflecting), which results in the conclusions and contributions of the main study of research, the Trace Project.

After each phase of the project, the families' sayings, doings and relating's were analysed using thematic analysis, an iterative approach that led on to the planning of the next phase of the project, while helping to answer the overall research questions:

RQ1: '*Can wearables and smart textiles aid intimacy within family communication systems'?*

and

RQ2: *'What is the role of co-design in the understanding and creation of such a system?'*

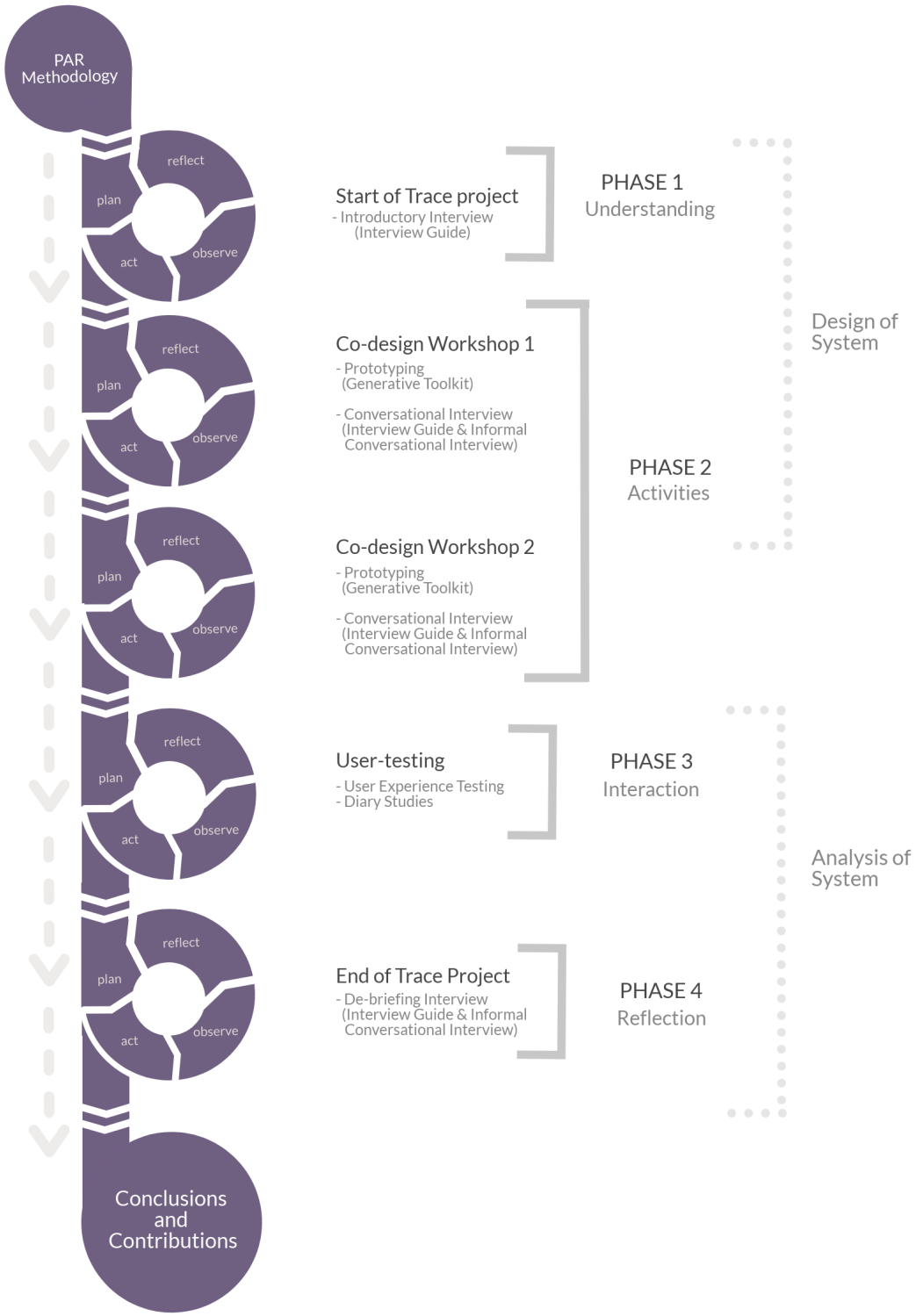

Figure 5.3 Trace Project Methodology, showing methods and key phases of the research

5.4.1 Use of Interviews within the Trace Project

The initial interviews were conducted at the start of the Trace project solely with the parents so as not to upset the children with any information relating to the family's separation. These interviews provided background information on the families, their separation types and their communication needs. An interview guide was created (Appendix 4.10), based on interview guidelines discussed in Section 3.3.2.5 Data Analysis.

The interview questions asked within the Trace project, were refined versions of those tested throughout the introductory stages of the small-scale studies. Through these iterations suitable questions and categories were decided.

Questions within the Trace project initial interviews were asked to gain backgrounds on the families, their separations, relationships and general information on their communication habits. For example:

- What technology or communication methods were used?
- How often?
- What times?
- Were there any barriers preventing communication at certain times?
- What were these?

Interviews lasted between 45 minutes to an hour, were conducted in person and were audio recorded and transcribed. The parents chose a suitable time and place for the interviews to be conducted, two were within the family home, while the children were out and one chose to come into the University.

The findings from these interviews provided information on how to plan and create the first stage of workshops and offered insights into which sort of activities, settings and format the families would best engage with.

Interviews were unstructured in format and were essential for being able to gain knowledge and key information about family dynamics at the start of the project as well as providing significant reflections on the process and interactions at the end of the project.
Interviews were an important part of the design process throughout, providing the opportunity to converse with the whole family and find out more about them as a unit and how they function.

Interviews were described as information sessions, rather than 'interviews', which offered a more relaxed and informal atmosphere for the families. At the start of the process a series of 'getting to know you' interviews, or discussions, took place with the parents, without the children, to discuss the periods of separation and reasons for them. This was important as some of the issues discussed (reasons for separation, time spent apart) covered sensitive subject matter that might have caused distress to the children when talked about frankly by their parents. Due to ethical constraints and good practice (see Chapter 3, Section 3.2.4), questions were always open and non-leading. There were very few set questions; instead general themes were used allowing families to elaborate where they felt the information was necessary and relevant to their communications and separation. Questions like '*How do you like to communicate with your children when you are apart?'* and '*Talk me through a typical working week*' were used, allowing the parents to share as much or as little information as they wished.

Good relationship building, with care and compassion, was essential not only for good ethical practice but this also allowed trust to form, which strengthened the research outcomes, offering better participant engagement within the process, as well as open honest answering and observations through the user testing phases. With any sort of social research which probes into personal matters, it is very important to avoid causing undue stress to the participants involved in the research. This was specifically important in this research, due to the sensitive subject matters being discussed surrounding family separation.

Interviews were used in this way throughout the process, more as general discussions through the interactive workshops, as well as at the end of the user testing phase, with each

family, to allow the researcher to validate the data collected from the Trace Communication System. It was of paramount importance to be able to understand some of the messages that were sent, especially from the children, as these would highlight specific issues that the system could address during further iterations of the Trace Communication System, as well as offering suggestions to others researching family communication systems. Future research is suggested in Chapter 6, and Section 6.4 *Future Directions of this Research*.

Table 5.2 Use of interviews in the Trace Project

When	Interview Style	Rationale
Start of Trace Project: Introductory Interview	Interview Guide	Information Generation: Standard interview questions asked to all adult family members (Appendix 4.10.1)
Workshop 1: Conversational Interview	Interview Guide / Informal Conversational Interviews	Further information on communication needs: General topics to be discussed – each topic was asked to every family, allowing them to elaborate on the topics that were important to them. (Appendix 4.10.2)
Workshop 2: Conversational Interview	Interview Guide / Informal Conversational Interviews	Further information / feedback on prototypes: General topics to be discussed relating to preference of object and system, features, aesthetics etc. Again, these general topics let the families elaborate on the areas that were important to them.

User-testing	User Experience Testing Diary Studies	Testing of the Trace Communication System Collecting families' direct responses to using the Trace Communication System
End of Trace Project: Debriefing Interview	Interview Guide / Informal Conversational Interviews	Debriefing session: 1. Reflection of process – allowed families to share their thoughts, feelings and comments on the process from recruitment, initial meeting (Introductory Interview), to the workshops, user testing and debriefing interview. 2. Reflection of the Trace communication system – allowed families to share their thoughts, feelings and comments on the Trace communication system. Using the families' sayings, doings and relating's to show how intimacy was created.

Table 5.2 Use of interviews in the Trace Project

Follow-up interviews were conducted at the final stage of user testing to:

- Reflect on the research process.
- Gain feedback on the design and operation of the communication objects.
- Gain feedback from all involved (what participants thought about the Trace Communication System).
- Compare data and analyse information gathered from the user-testing of the Trace Communication System.

- Further analyse the diary studies to get a clearer picture of what had transpired and how each participant felt during the testing period (part of the data analysis, Section 5.7).

The User testing phase of the project (in grey), table 5.2 was the only phase of the project where interviews were not used to collect data. The data collected here was from the timings and frequency the families used the Trace Communication System and the families' direct responses to using the Trace Communication System, which were recorded in their diaries. An *interview guide* was combined with *Informal Conversational Interviews* for use within the workshops. Specific topics were prepared such as preferred communication types, objects, real time, time delay etc. which were to be discussed throughout the workshops (See Appendix 4.10 for full Interview guide). Therefore, each family was asked the same questions on the same themes enabling their thoughts on specific themes to be captured which allowed their sayings to be categorised into coding schemes for analysis.

While *Informal Conversational Interviews*, allowed for the predetermined topics to be discussed, re-visited and deepened, without the family's feeling like they were being interviewed. Further questions on the topics were organic and came from the discussion, allowing the conversation to be focussed, while permitting ideas to meander into sometimes surprising territories (Patton, 2015, p342).

5.4.2 The Use of Photography

Family participants were encouraged to take their own photographs (which generally happened via their mobile devices) to document their experiences throughout the Trace Project. This documentation (photographs) offered the researcher insight into the families' 'doings' through the user testing phase. They were a window into the families' experiences with the Trace Communication System, when the researcher was not present to observe these first hand. Thus, photo documentation helped to contextualise the families' 'sayings' and 'relatings' from the automatic recording of their 'doings' (timings and number of interactions with their communication objects), through their self-reporting in their diaries

and through final discussion in the concluding interviews that took place after user testing of the Trace Communication System. The documentation of daily life events has become commonplace since the creation of social media sites, especially Facebook, Twitter, Flickr and Instagram (Jensen, 2014; Burns, MacLachlan, and Rees, 2016; Sheldon and Bryant, 2016). Thus, it was of no consequence to the families to record their involvement with the research through photo documentation, and for the most part it happened automatically, without the researcher having to request it.

Photo documentation was also used by the researcher (with the consent of the participant families) to record the families' 'doings' in workshops as well as their 'relatings' through the initial set-up of the Trace Communication System. This captured their initial reactions to the Trace Communication System, which is useful when disseminating the findings, as it shows a record of happenings.

5.4.3 Co-design Workshops

The first workshop was carried out at the start of the process (see Section 5.4.3.1 *Workshop 1*) in April 2013, and another midway through the prototyping phase, in August 2013 (see Section 5.4.3.2 *Workshop 2*).

Workshops were used both for idea generation, and as a method of building relationships and trust between the families and the researcher. The say, do, make model was followed, allowing the families to talk about their experiences and needs through interviews and discussion, to act out scenarios through generative toolkits and workshops and to make their 'dream' communication objects and systems through lo-fi prototyping. The workshop environment offered an opportunity to gain a better understanding of family dynamics and individual personalities, whilst helping to build trust through fun semi-structured activities, such as drawing, discussion, and lo-fi prototyping. The workshops offered a safe and relaxed space (studio setting for Workshop 1 and within the family home for Workshop 2), where participants could discuss and play with the designed activities. This aligned with Gillham (2000), and Patton (2015), ideas of creating 'safe spaces' for interviewing and data

collection. The activities were created to elicit the required information for producing the Trace Family Communication System, whilst offering the families fun activities where they could work as a team to discuss and think about their separation issues in a positive way. The activities challenged participants to think about how they could improve family communications when apart, whilst being empathetic to one another's needs, and considerate to what each family member (including themselves) required from their proposed communication system. Per Ólafsson, Livingstone and Haddon (2014, p25) "*Answering an adult researcher's questions seemed to be easiest for a child when they were allowed to engage in some meaningful activity e.g. drawing or playing during the interview*". Thus, the families were mainly interviewed through workshops, where they engaged with generative toolkits and prototyping, methods which allowed the families, especially the children, to think through making, uncovering their true feelings and latent needs surrounding family communication systems.

Before the first workshop the idea of having part of the communication system as an app on a mobile device had been rejected due to the nature of the device itself. It had been categorised within the contextual review as a screen-based, hard two-way communicator, and this was not suitable for children to use, because of its cost, safety issues, low intimacy values and complex usability.

However, this thinking may have been slightly naïve. A mobile app would not be suitable for the children's communication objects, as shown throughout this research, but is a viable option for the parent's communication object. This is due to the varying communication needs of parent and child, and the types of information they require. Per Buechley *et al*. (2013), cost is a major factor when considering mass integration and adoption of smart textiles and wearable technologies, thus, it made sense to utilise existing technologies already used in 21st Century family life. Convenience and integration of the communication objects were paramount to them being used. Thus, it was rational to combine the parent's communication object with an existing object. Parents had favourable reactions to an app on their phone, as evidenced in workshop one, and, when revisited in workshop two, it was confirmed that an app would be used as the parent's communication object. Adults with developed communication skills and clear understanding of their emotions and separations

can use seemingly non-intimate technologies in ways to give them intimate value. Thus, it is the way that technology is used that gives it perceived intimacy, and not the object itself.

> **Parents stated** "*While I think it would work for us* (the parents' communication objects) *I would not be happy, no way, giving my child a smartphone so they could contact me, they are too young, I couldn't afford to give both of mine phones, besides I don't think it's necessarily safe, you don't know who they might end up calling or who could contact them, then there is the internet…I mean it's not safe… no apps for the kids a definite no I'd say*" (Parents, 2013), and "*I feel they have too much screen time anyway, it would just be used as another excuse to watch YouTube and the likes*", "*something more fun and interactive that, I dunno, would make them more animated or get up and do things would be good*", "*a toy? Or something 3D and physical that they could push buttons or talk to us through*", "*something simple, perhaps that they could get messages from us and could send back emotions*?" (Parents, 2013).

The children's communication object is different and needs to have intimate value embedded within the object itself to aid intimate communications. This is due to the children's communication needs as well as their understanding of all the relevant issues such as technology, language (written and oral), their emotions and their separations. They also needed an object that was convenient to them and could be easily integrated into their daily lives. Thus, they decided on a toy.

> **Children stated**, "*I would like a toy, that'd be really cool*", "*Awesome a toy! Could we have secret messages?"*, "*Can we send messages like smiley faces like on messages*", "*Yes, Mummy, like on Facebook* (laughs excitedly), *I can send you sad faces when Daddy gives me stinky broccoli for tea*" (Children, 2013).

5.4.3.1 Workshop 1

The first workshop was a group workshop where all three families attended together, in a studio setting, at Duncan of Jordanstone College of Art and Design, a faculty of the

University of Dundee. The families worked, within their family group, to discuss and create their 'dream' communication objects before sharing their ideas and lo-fi objects with all the other families and the researcher at the end of the day.

During this workshop the concept of designing their own personal family communication systems was introduced to the participant families. A generative toolkit was created for the workshop, which included participant worksheets, paper, pens, junk material, glue, scissors (see Chapter 3, Section 3.3.2.2). This aided in the families' idea elaboration and discussion throughout the workshops. Essentially it allowed the participant families to think through making and learn through doing (Dewey, 2007; Adamson, 2007; Papandreou, 2014).

The families were given structured worksheets to complete that were used as 'ice breakers' within the process, providing valuable information and background about each family (Appendix 4.7.1). Essential information was acquired from these toolkits, such as the way in which the family currently communicated, the way they played together, and their favourite personality traits in each other as well as descriptions of each of their favourite items. Ice breakers are used at the start of an event, workshop, meeting or gathering, to allow people to get comfortable with their surroundings, the topic they will be focussing on and to get to know others they will be working with (the other participants and the facilitator of the activity). They are generally fun, non-threatening, fact-finding games that should make the participants feel relaxed about the about the activities that follow (Visuals Speak, 2015; Mindtools, 2017).

Participant worksheets and lo-fi prototyping, part of the generative toolkits, were used to enable the families to feel comfortable with the making process and to help them visualise their ideas for their ideal communication systems. Idea elaboration (Druin, 2002 and Guha, Druin and Fails, 2013), allowed family members to share and expand ideas collectively, shaping thoughts and verbalising concepts.

Firstly, families were encouraged to draw their family groups favourite objects and fantasy communication objects (both as a collective and individually), via the

participant worksheets.

Secondly, families were given 'junk' materials to build their communication objects (lo-fi prototypes), materials such as old yoghurt pots, crisp tubes and cereal boxes (Figure 5.4). Using a lo-fi making process gave the participants confidence in the task and their making skills, as the finished article wasn't expected to be amazing. Lo-fi prototyping also meant families were not nervous to experiment with the materials present, as the cost of them was very low, meaning they were not concerned with ruining expensive equipment or getting things wrong.

Thirdly, families reflected upon the communication systems they had created via group presentations and discussion.

The use of generative toolkits in workshops was a useful method to introduce the families to the making process, especially for the grown-ups as many of them had not participated in any sort of making (arts and crafts activities) since they were children themselves.

Figure 5.4 Family in workshop 1 with their information sheets

Lo-fi prototyping, along with participant worksheets, allowed the participants to work through their ideas. These tasks took the participants through various stages of 'dreaming' and designing where they were encouraged to think about their ideal family communication system (Figure 5.4).

The workshop offered insights into family dynamics, communication issues and timings to be considered (work/school/extracurricular scheduling), as well as the communication experiences a family communication system should offer. No communication idea or method of delivery was 'off limits' during the co-design workshops. Pure fantasy could be engaged in, with one family prototyping a hologram projector (Figure 5.6) as part of their family communication system, much like that from their favourite film *Star Wars*. A hologram feature at the time of Workshop 1 seemed impossible, but this feature was represented, within the Trace system, through the use of an Android mobile phone that had an integrated projector (Samsung Galaxy Beam), along with the Skype application. The workshop provided the researcher with the key information on all the 'must-have' features that would be integrated later in the Trace Communication System.

Figure 5.5 Selecting objects

The information generated provided a solid knowledge base to begin the conceptualising of what a two-way communication system for parent and child would look like, and what functionalities it should have.

Key Learning from Workshop 1:

The first workshop offered great insight into each family's wants, needs and desires, and highlighted the different information sharing and emotional needs of each participant. The children sought fun, intimate interactions, and wanted to know in a playful exciting way that their parents were thinking of them. They wished to have personal 'secret' messages that only they could access:

> "*I want my mummy to send me a secret message that no one else can see, not even my sister or daddy, or granny, that would be so cool*" (Children, 2013).

Whilst the parents, conversely, wanted to know more about their children's basic needs and wellbeing, for example:

> "*Had they eaten their lunch?*", "*did they complete their homework?*", "*had they had fun at their friend's birthday party?*" (Parents, 2013)

Or they just generally wanted to know where their children were and if they were safe:

> "*Can we have a tracing feature?... I've seen wristbands that can do that, I'm sure somewhere, and thought it was a good idea, not sure how that works, but would put my mind at ease I think to know they were at home or school or their granny's…*" (Parents, 2013).

Due to the type of information the parents desired, and taking into consideration their current lifestyles (work), it was decided that the parents would have an application on their phone and not an object. This would fit into their busy lifestyles and it was agreed they would remember and use it more as they would not have to remember another thing when

leaving for work:

> *"I don't think a textile object would work for me personally, I mean, I get that it would be good for the kids, as no way I'm giving them a smartphone or tablet, they are too little, but I already have so much to remember. I'd feel guilty if I forgot the object, which is very likely. I would much prefer an app on my phone or something"* (Parents, 2013).

> *"Yes, I must agree with *****, an app would be much better, more discreet you know. I mean I can't imagine whipping out a cushion or something in a meeting for a cuddle (laughs)… also like ***** says I would never remember to take it and the size is concerning me slightly too, I need the object to fit it into my bag or pocket for traveling around, unless it's something that just stays in the house?... but I am away so much it would almost be pointless you know?"* (Parents, 2013).

> *"Yes I think an app, or something pocket-sized, would be better for me too"* (Parents, 2013).

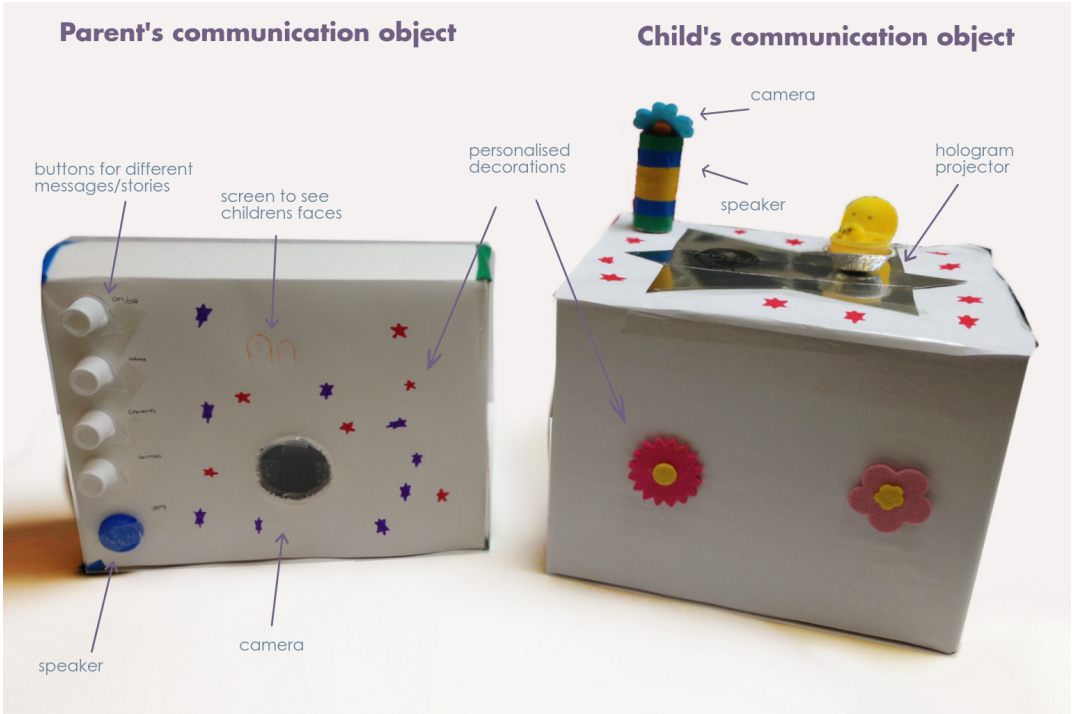

Figure 5.6 Family A's final communication system

5.4.3.2 Workshop 2

The second workshop took place with families A, B and C individually, in their respective homes (Appendix 4.9.2), to gain further information about their needs and wants from the Trace Family Communication System.

Most of this information came from another set of worksheets and from fun creative family drawing activities. The 'home' setting was beneficial, as it created a relaxed environment, ideal for informal chats (Figure 5.7 and Figure 5.8).

Figure 5.7 Family discussing and recording likes, dislikes on their worksheets

Within the second workshop, families were also presented with prototypes, ideas, information and early sketches for the communication objects (children's toys and parents'

app) from the initial workshop to capture feedback and insight for the further development of the communication objects for the final Trace Communication System.

Data generated from the second workshops focussed on the specific aesthetics (colour, materials) and features (function and modes of communication) each communication object would offer (parent's and child's). This allowed for the personalisation of each individual's communication objects (parent's app and child's toy) within each individual family's communication system.

It had been decided within the first workshop (by both parents and children) that the children would not be having a mobile device as their communication object, due to cost, safety and security issues as well as the parents feeling that their children already had:

> "*Too much screen time*" and "*high levels of exposure to technology*" (Parents, 2013)

Key Learning from Workshop 2:

The second workshops offered a deeper insight into family dynamics, important issues, communications and problems within current communication systems. They allowed the families to describe specific communications they wanted each communication object to have, while offering further input on the aesthetics of the toy and app.
The children were eager to hear more about their communication objects and their possible features, as well as aesthetics, at the second workshop stating:

> "*My toy will look like my drawing that's so cool, can it be pink like my drawing too? Pink is my favourite colour, look, I am wearing pink socks and have a pink top*", "*Daddy, Daddy it's going to have the Star Wars holo projector (giggles) you will be like the princess Lela* (referring to Princess Leia from the film *Star Wars Episode IV – A New Hope*) *how awesome is that?"* (Children, 2013).

The following tables (5.3 and 5.4) show the main findings from the second round of workshops. They detail the key requirements for both parent (Table 5.3) and child (Table 5.4), in terms of object choice as well as the information and types of intimacy sought by each family member from a communication system.

Figure 5.8 Family discussing and recording likes, dislikes on their worksheets

Table 5.3 Parents Requirements

Object:	*Information needed:*	*Type of Intimacy sought:*
- *App* *Features:* - *quick and easy to use* - *one and two-way communication* *Aesthetics:* - *Simple icons* - *User friendly* - *Personalised to family*	- Childs happiness - Childs safety - Childs basic needs being met (e.g. are they fed, suitably dressed for weather conditions, adequately supervised) - Childs whereabouts	- Mutuality - Cognitive - Affective

Table 5.3 Parents Requirements

Table 5.4 Children's requirements

Object:	*Information needed:*	*Type of Intimacy sought:*
- *Plush Toy* *Features:* - *easy to use* - *one and two-way communication* - *fun and playful interactions* *Aesthetics:* - *Friendly* - *Personalised*	- Reassurances from parents (e.g. that they are loved, missed, home soon)	- Mutuality - Cognitive - Affective - Commitment

Table 5.4 Children's Requirements

5.4.7.3 Key Learning from the Trace Workshops:

The families' need for function and 'beauty' was intrinsically linked to the levels of engagement and intimacy gained from using the communication objects (Wallace and Press, 2004; Wallace, 2007; Wallace, Dearden and Fisher, 2007; Wallace 2014). Adoption of the objects is dependent on the value they bring through usability, aesthetics or sentimentality (see Chapter 2, Section 2.6.2).

During the creation of the children's toys, some of the key delivery criteria were missed because of the delegation of control of certain tasks, such as the physical making of several of the toys. The levels of engagement and connection the two older children (aged seven

and eight) felt with their toys may have been compromised through their creation. These small details become especially significant when working under tight aesthetic or functionality constraints through a co-design process.

It became apparent during the user testing of the Trace Communication System that this had become an issue. An initial toy pattern had been designed that would house the technology (key components) within Child A's toy (Figure 5.9). However, the internal patterns and pathways for the technology (key components) were complicated. The initial pattern was altered, by the textile designer, to make the toys more uniform so the technology could be safely contained and would be easily interchangeable. This resulted in the toys' construction taking up more of the textile designer's time than had been anticipated, taking her focus away from the toy's appearance. Thus, some of the key characteristics from the children's drawings were 'lost in translation' and so were missed, characteristics such as colours, shapes of facial features, proportion, while other features were added, such as buttons and bows. The misrepresentation of the older children's drawings caused confusion and instant indifference to their communication objects (Figure 5.9 and 5.10) with them saying:

"*It doesn't look like my drawing*" (Child B, 2014),

"*Did I draw that? My drawings are much better usually*" Child F (2014).

Whilst the toys resembled the children's drawings they did not always capture the true characteristics that the children and drawn, which prevented the older children from engaging with their toys. Thus, communication to third party contractors is vital at each key stage of the making process, and through every design decision.

Aesthetic fidelity became a key consideration for the research outcomes and this will be discussed further in Chapter 6, Section 6.4.

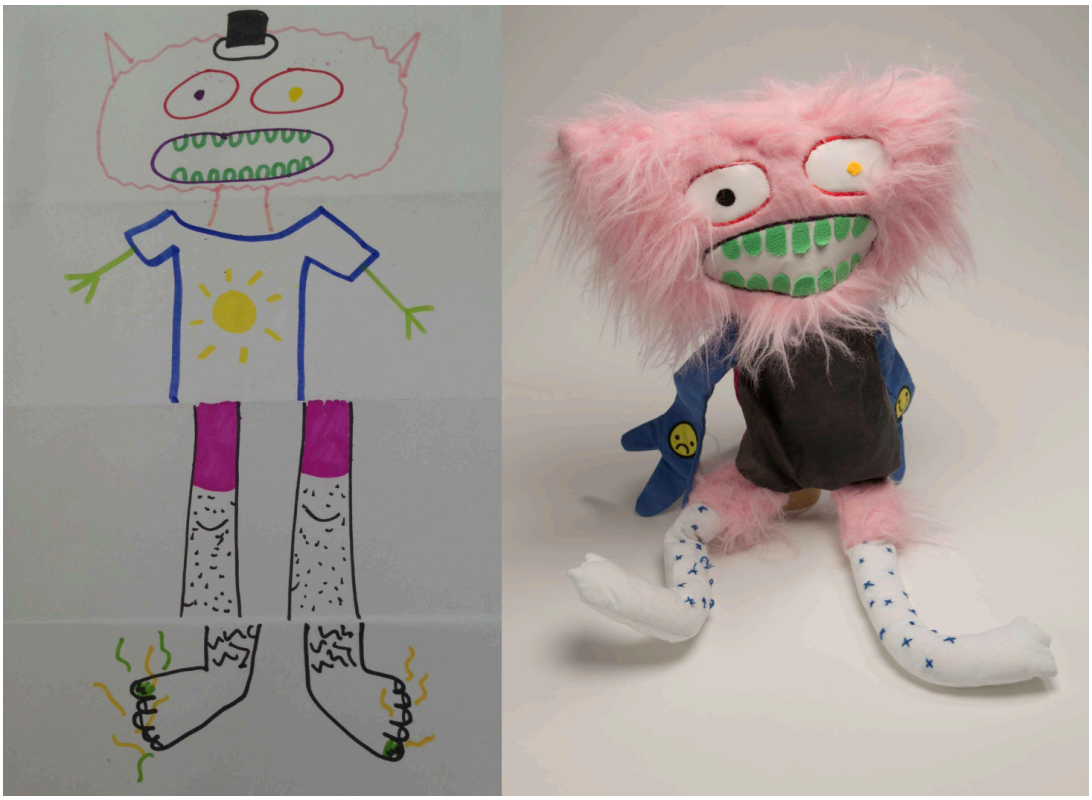

Figure 5.9 Child A's drawing and final communication object

Figure 5.10 Child B's drawing and final communication object

Key Points from the Families on Family Communication Systems:

Objects:

Children – a toy
Adults – a phone application

Types of communications:

Children – fun and intimate interactions from parents
Adults – happiness, safety and wellbeing of child

5.4.7.4 Collaboration and Communication within the Co-design Process

Due to the different disciplines and expertise needed to prototype a fully working family communication system such as Trace, collaborative working was essential (Venkatesh, Brown; Bala, 2013). Thus, as well as family collaboration (co-design), a multidisciplinary team (participatory design) was put together. The following sections on the participant families and the multidisciplinary team outline the positives and negatives this type of collaborative working brings to the design process.

5.4.7.4.1 Families

Positives:

Collaboration - from the two co-design workshops and discussions with the families the data needed was gathered, enabling the design and technical team to produce a fully working prototype of the Trace Communication System. The data included all the design decisions made by the families, such as the suitability of communication objects (for both parent and child), the interactions each object would have and the usability of the Trace Communication System along with its aesthetic features.

Obstacles:

Availability - family life can be hectic, disorganised and ever changing. Family research needs to be dynamic, as family life can often lead to planned activities,

such as workshops, interviews, activities, being changed and/or cancelled at short notice. The pressures on family time, and modern family life, can leave participants (parents and children) lacking the required time or energy for full engagement in workshops, activities and discussions. As a mother, I understand family life, and empathise with these varied and often unexpected situations. Organisation and contingency plans ensured that there were always alternative times and places for workshops and discussions with families (to gather the required data for each stage of the research process) to avoid negative disruption to the timeline of the research. Contingency planning was implemented effectively, by scheduling workshops and meetings well in advance of any personal deadlines for the project, offering flexible timings if the families' availabilities changed, or if more time was required to resolve certain issues. However, this was never an issue with the families, and especially the children, as they were very enthusiastic in all the activities and engaged well in the discussions surrounding the Trace Project.

Finding common ground and language **-** It is important to use simple language, no technical jargon and explain in a way both parents and children will understand.

5.4.7.4.2 Multidisciplinary Project Team

Positives:

Collaboration **-** good collaboration with the technical team (programmer, app developer and engineer) enabled a fully working prototype of the Trace Communication System to be created and tested by the three families involved with the Trace Project.

Obstacles:

Finding common ground and language **-** good communication is an important factor when working in a multidisciplinary team, fundamental, as it is, to the effective

sharing of the ideas, methods and goals of a project.

Deadlines **-** meeting deadlines and targets is especially important with time-sensitive research, such as thesis work, where projects must be achieved and results delivered within an allocated time.

Delegating and control - whilst delegation and handing over control of tasks is a wonderful and, in some cases, essential part of any project or design process, it can become problematic when bringing in 'outside' technical help.

For more information regarding the multidisciplinary project team, and collaborative working process, please see Appendix 4.2.

Summary of Methods

A series of the collaborative methods that were used to create and evaluate the Trace Communication System, the physical output of the Trace Project, has been discussed. Technical action research aided the design of the Trace Communication System as it *"is intended to increase the relevance of artifacts, just as other forms of action research aim to increase the relevance of knowledge"* (Wieringa and Morali, 2012, p. 220). It made the data generated by the families, through workshops, interviews, self-reporting, observation, accessible to the multidisciplinary team (researcher, programmer, textile designer, and engineer), enabling them to achieve the interactions the families wanted in their communication system. This resulted in a family communication system prototype(s) that was robust enough for three days of user testing with the participant families.

In the next section, the elements of the Trace Communication System will be discussed in detail, outlining the objects (plush toy, textile house, participant diaries, storybook and follow-up postcards), hardware and software involved in the Trace Project.

5.5 The Trace Communication System

The Trace Project consisted of the following:

- ***Objects*** (1. toy, 4. textile house, 5. book, 6. diary, and 7. postcards) (Figure 5.11)
- ***Hardware*** (2. key components and 3. mobile phone)
- ***Software*** (3. phone application)

These are illustrated in Figure 5.11 and will be discussed in detail in the following sections, *Objects* (Section 5.3.1), *Hardware* (Section 5.3.2) and *Software* (Section 5.3.3).

Figure 5.11 Trace Communication System: child's objects

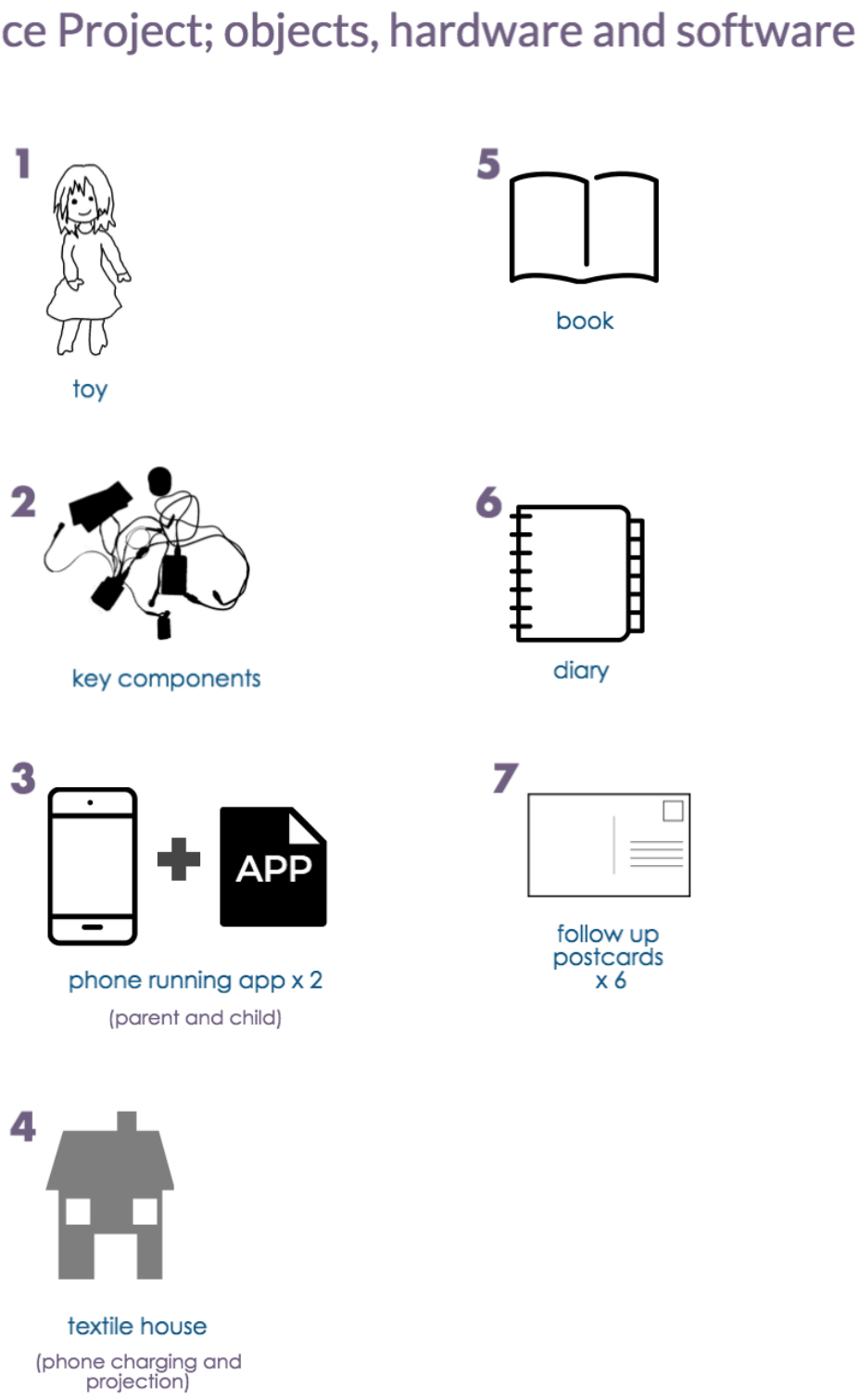

Figure 5.12 Trace Project: objects, hardware and software used within the research

Objects (see Section 5.5.1)

- ***Plush Toys*** (1) - child's communication object
- ***Textile House*** (4)- for charging and projection of Skype call
- ***Book*** (5)- a storybook to explain the Trace Communication System to the families
- ***Diaries*** (6) - to record feelings about using the system
- ***Follow-up Postcards*** (7) - a way of transitioning for the children from having the system to not having the system

Hardware (see Section 5.5.2)

- ***Key Components*** (2) - *Arduino UNO* R3 (aided the communications between the child's toy and the mobile phone), *wireless Bluetooth speaker* (played the parent's audio message to the child, through their toy), *push buttons with vibration actuators* (allowed the child to send happy or sad messages to their parents as well as initiate a Skype call by pressing the toy's hands or mouth), *Bluetooth adapter* (allowed the Arduino UNO R3 to connect to the speaker), *battery pack* (powered the child's mobile phone and the Bluetooth speaker for a maximum of three days), *heat pads* (revealed the secret message when activated), *9v batteries* (powered the heat pads).
- ***Mobile Phones*** (3) - parent's communication object and controlled the communications of the child's toy.

Software (see Section 5.5.2)

- ***Trace App*** (3) - ran the whole communication system, determined what action sent which reaction, i.e., when the 'happy button' was pressed on the child's toy, it sent a happy notification which was displayed on the parent's app.

The Trace Communication System offered the families several different modes of communication, as well as different communication objects (Figure 5.12), due to the diverse needs of the family members. Parents' interactions focused on factual information about their children's happiness, wellbeing and whereabouts, whilst children were seeking reassurances of love and the presence of their parents through their communications.

The following sections will describe in detail the objects, hardware and software of the Trace Communication System.

5.5.1 Objects

The two communication objects present in the Trace Communication System were: 1. a plush toy, used as the children's communication object (which had an internal mobile phone which ran the Trace App, along with the key components which allowed the toy to function as a communicator), and 2. the Trace App (which ran on the parent's mobile phone), used as the parent's communication object (Figure 5.13).

Figure 5.13 Child's communication object (toy) and parent's communication object (phone application)

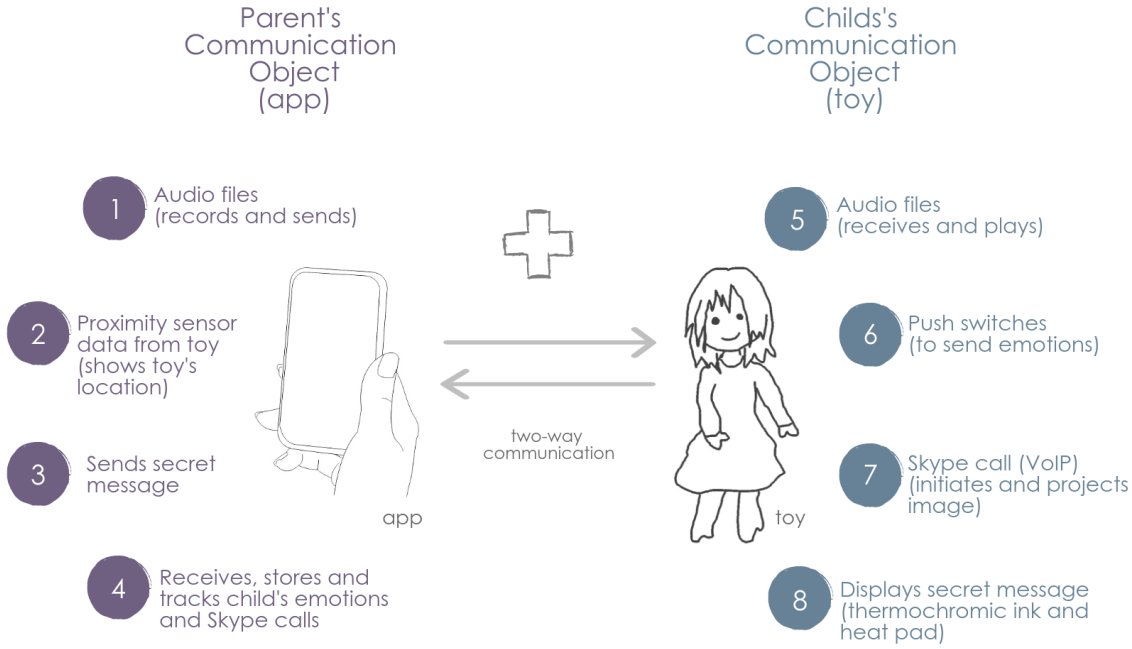

Figure 5.14 Displays communications of the Trace Communication System

Each communication object offered different modes of communications (Figure 5.14) and these are detailed below.

Parents could communicate with their children by:

- Recording and sending audio messages from their app (1) to the child's toy (5) (Figure 5.15).
- Viewing and tracking the location of their child's toy (2).
- Sending a secret message (pictorial semiotics) (3) to the child's toy (8).
- Receiving their child's happy or sad messages (4 and 8) as well as accepting their child's Skype call (4 and 7) (Figure 5.15).

Children could communicate with their parents by:

- Listening to the audio messages sent by their parents (1) through their toy

(5). The message played through a speaker in the toy's head, as if the toy were repeating the message.

- Sending happy or sad messages to their parents through their toy. This was initiated by pressing the happy or sad button located on each of the toy's hands. Haptic feedback was offered (vibration) so the child knew the message had been sent (4 and 6).

- Calling their parents on Skype. This was initiated by pressing the toy's mouth and haptic feedback was offered (vibration) so the child knew the call was being placed (4 and 7).

- Seeing the secret message sent by their parents, which was displayed on the stomach of their toy (3 and 8). The message was shown when the heat pad beneath the message was activated (by the parent), causing the thermochromic ink (that hid the secret message) to heat up and turn clear, revealing the message below (Figure 5.15). This used the idea of pictorial semiotics, using images and drawings to convey meaning and send messages, without the need for vast textual explanations. This allowed for the meaning of the messages to be easily understood by the children.

Figure 5.15 Child's toy showing the secret message communication

Figure 5.16 Parent's object: mobile phone and the Trace App

5.5.1.1 Toys

The child's toy (which contained a mobile phone) was personalised, as they were created for each individual child, based on their drawings from workshop participation (Figure 5.17) (see Appendix 4.7 for images of all the children's drawings and toys).

The child's communication object needed to include a mobile phone to allow many of the communication features to function, such as the Skype call, projection and the sending and receiving of messages (happy, sad, audio), both to and from their parents.

The children played with their toys (hugging and squeezing) to initiate communication with their parents (proxy co-presence). Parents received feedback on their child's interaction with the toys (which was directly stored in the application on their phone, as well as on a central server), allowing them to monitor how and when the toy was played with, as well as the toy's location (a recommendation from the parents).

Parents communicated with the child by sending messages through the application (app) on their phone directly to the toy, in audio (voice messages) or visual (secret messages).

Figure 5.17 Child with her personalised communication object (toy)

5.5.1.2 Textile House: Charging and Projection of Skype

The children were given the Trace House (Figure 5.18) alongside their toy (communication object). The Trace House was used to charge the child's phone (Samsung Galaxy Beam, which had a projection capability) and when a Skype call was to be placed, enabling a video image of the parent to be projected onto the child's bedroom ceiling. Skype projection was used so the parents could tell their child a goodnight story or have a chat with them, without the child directly looking at a screen. This feature came from the initial co-design workshop of family A's communication system (see Section 5.3.2.1).

Figure 5.18 Trace House

The phone is only in the textile house when the child is in their bedroom (where the textile house is situated). When moving around the house, or when leaving the house, the child's phone must be placed back inside the toy, by the adult who is responsible for the child's care at that moment. The child's mobile phone controls the Arduino board within the toy, and it is therefore the 'brains' of the toy, directing all of the information that is sent to and from the toy.

The child initiates a Skype call by pressing their toy's mouth and the parent's image is then projected onto the child's ceiling from within the Trace House. This meant that the children were not looking at a screen (Figure 5.19 and 5.20). The 'screen-less' communication method for the child was an important requirement that the families requested of the Trace Communication System. This aspect was exciting, as the research had shown that screen-based communication objects were not the most effective modes of communication for intimate connections with children. The projection offered a sense of magic and wonder to the children. It was a new way of 'seeing their parents' that made them feel "*closer*", parent of Child C, (Parents, 2013) and as "*if they were in the room*", child aged 4 (Children, 2013).

Figure 5.19 Trace House, showing the child's phone, the Samsung Galaxy Beam docked inside

Figure 5.20 Trace House in child's room

5.5.1.3 Book

In conjunction with the toy and phone application, families were provided with a Trace Book (Figure 5.21). The Trace Book was an 'owner's manual'; it explained the Trace Communication System and offered instructions for use. It was presented as a children's storybook with clear information on how the Trace Communication System worked, with large friendly illustrations, and a charming story (Figure 5.22 and 5.23). It helped the children to understand how the Trace Communication System worked, what interactions they could initiate and how parents could respond. It also made them aware that the communication system was with them for a short testing phase only, and would not be a permanent feature in their lives and family communications.

It was imperative that the Trace Communication System was presented to the families in a fun and user-friendly manner, allowing them to further engage with the communication system they had co-designed. Family engagement would provide the best results from user

testing and would allow for better understanding of family communication systems and aid in the contributions to knowledge.

Figure 5.21 Trace Book

See Appendix 4.3 *Trace Book,* for full size images of the Trace book.

Figure 5.22 Trace Book extracts

Figure 5.23 Trace House: extract from Trace Buddy's Book, how the Skype projection works

5.5.1.4 Diaries

Diary studies were used during the Trace Project to gain immediate emotional reactions, observations and feelings stimulated by using the communication objects from both the parent's and the child's perspectives. Both parent and child had their own diaries, which they were requested to complete after each interaction (Figure 5.24). Sometimes this was difficult due to work schedules for the parents or lack of literacy skills for the child (depending on age). However, the children all found at least two instances over the day when they could sit down and fill in their diaries, with an adult or older sibling to help if necessary. The participants used words and graphics to describe how they felt when using the Trace Communication System. In the case of younger children, who could not read or write yet, the adult who was charged with their care (usually their other parent) annotated their thoughts and feelings for them. Both parents and children also used drawings, photographs, colours to illustrate their thoughts and feelings as a result of using the Trace Communication System.

Figure 5.24 Buddies Diary

Information gained through the diary studies was used to verify or dispel the insights gained through the families' user testing of the Trace Communication System. This allowed for the validation of certain findings. These were then based on the families' 'doings', 'sayings' and 'relatings', and not solely on their 'doings', giving a clear picture of how successful these types of family communication systems are within remote family communication, and the methods that were used to create them.

5.5.1.5 Postcards

The children were sent a series of Trace Postcards (transitional objects – Figure 5.25) from their toy (communication object), with short stories on each telling the children where their toy was now, along with a personal message to the child from toy, about how they were now helping other children to communicate with their remote parents. Transitional objects offer a way of helping children to transition from one stage to another, and are normally associated with babies in early life, such as security blankets, soothers or favourite plush toys (Newson and Newson, 1963; Winnicott, 1986).

It is not just the objects themselves that hold meaning for the child, it is the feelings they associate with the objects, i.e., a blanket or plush toy can have associations with the mother rocking or cuddling the child at bedtime (Gaddini, and Gaddini, 1970). Within the Trace Project the child's toy offered this connection to their parents so when this was removed (the functioning Trace Communication System), it was important to offer the children an explanation they would understand as to why their toys had left or no longer offered their previous communication possibilities.

The Trace Postcards offered the children a greater understanding of their toy, and the reasoning behind why their toy had left or no longer functioned as it had done before. This was done through the creation of personas of other children and their family separation issues. Postcards featuring these personas were then posted to the children after the user testing phase of the Trace Communication System. These postcards bridged the gap and helped the children transition from having the Trace Communication System, to not having

the fully working system (children had the option to keep their toys, minus the technological components), as a method to cause the least amount of stress possible for the families.

It is important when trying to make positive changes, especially within vulnerable groups (children in the case of this research), to avoid offering them methods of support (generally research related), then removing this support, and disappearing without some sort of debriefing exercise. If no explanation is offered to the children, they may become distressed and this could result in the families having more communication issues than they had before the researcher's intervention. It was also vital to inform the families (participants of the research process), at the start of the research process, that whatever is on offer is a test, an example of what could be, and not a final solution, making sure they are happy to proceed with the project having all the information. This is a key ethical consideration for any research project and should be explained within original conversations and through the participant information sheets (see Chapter 3, Section 3.2.4 Ethics).

Figure 5.25 Trace postcard examples

See Appendix 4.5, *Trace Postcards*, for full size images of the Trace Postcards showing illustrations of Buddy, the purple monster, and his adventures connecting personas of children to their parents all over the world.

Furthermore, it is extremely important when carrying out this type of research to not 'helicopter in' with promises, wonderful ideas and prototypes and then exit suddenly, leaving the participants, and in this specific research case, the families, with nothing and feeling somewhat frustrated by the lack of a new communication system. The participants may be more aware of the problem or issues after the project but without the 'magic fix' they will most likely feel empty. In this research, it was especially important for the children not to be left in this manner and therefore the Trace Postcards were sent to the child from their toy, after the initial testing phase, explaining why their toy had to leave and that they were off helping other families communicate now instead. The postcards offered the children closure on the project, and, in some cases, a sense of joy that their toy was now off helping other families connect with each other in the same way.

5.5.2 Hardware and Software

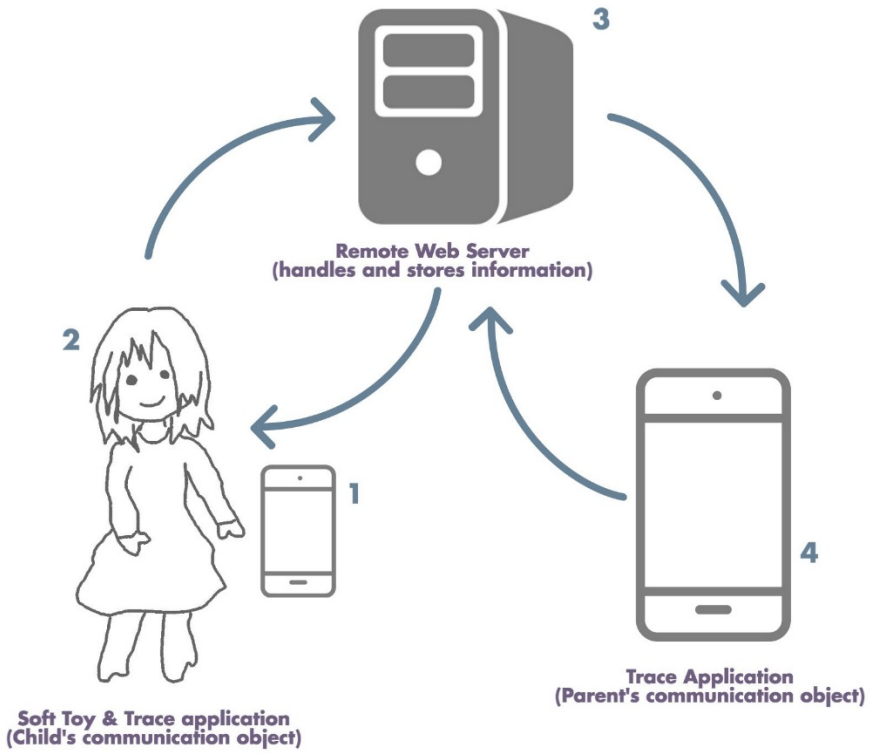

Figure 5.26 The four main components of the Trace Communication System (set-up)

The four main components of the Trace Communication System (set-up) are as follows (Figure 5.26):

1. A mobile phone running the Trace App located within the soft toy (child's side)
2. The Arduino-enabled toy
3. The remote web server
4. A second phone running the Trace App (parent's side)

For the child's toy to have the ability to send and receive communications, a mobile phone running the Trace App (1) was placed inside the child's toy (2). Thus, both parent and child's communication objects ran the Trace App and included a mobile phone (1 and 4). However, the child did not interact directly with the mobile phone (1), they interacted with the toy (2), and these interactions, through the Arduino, sensors and actuators, understood and actioned the communications. Thus, the Trace Apps (parent's and child's) allowed the flow of communication to and from each communication object, via the central remote web server (PHP) (see Figure 5.26).

The PHP web server (4) communicated with the mobile applications (1 and 4) using secure HTTPs. All the data stored on the server was encrypted before it was saved in the database. The encryption key was unique to each individual family account, meaning all the data stored, was secure for privacy and data protection purposes.

5.5.2.1 Key Components

The Trace toy components (description of the technology present in Figure 5.27) are as follows:

- ***Arduino UNO R3***
- ***Wireless Bluetooth speaker***
- ***Push buttons*** (with vibration actuators)

- *Bluetooth adapter*
- *Battery pack*
- *Heat pads*
- *9v batteries*

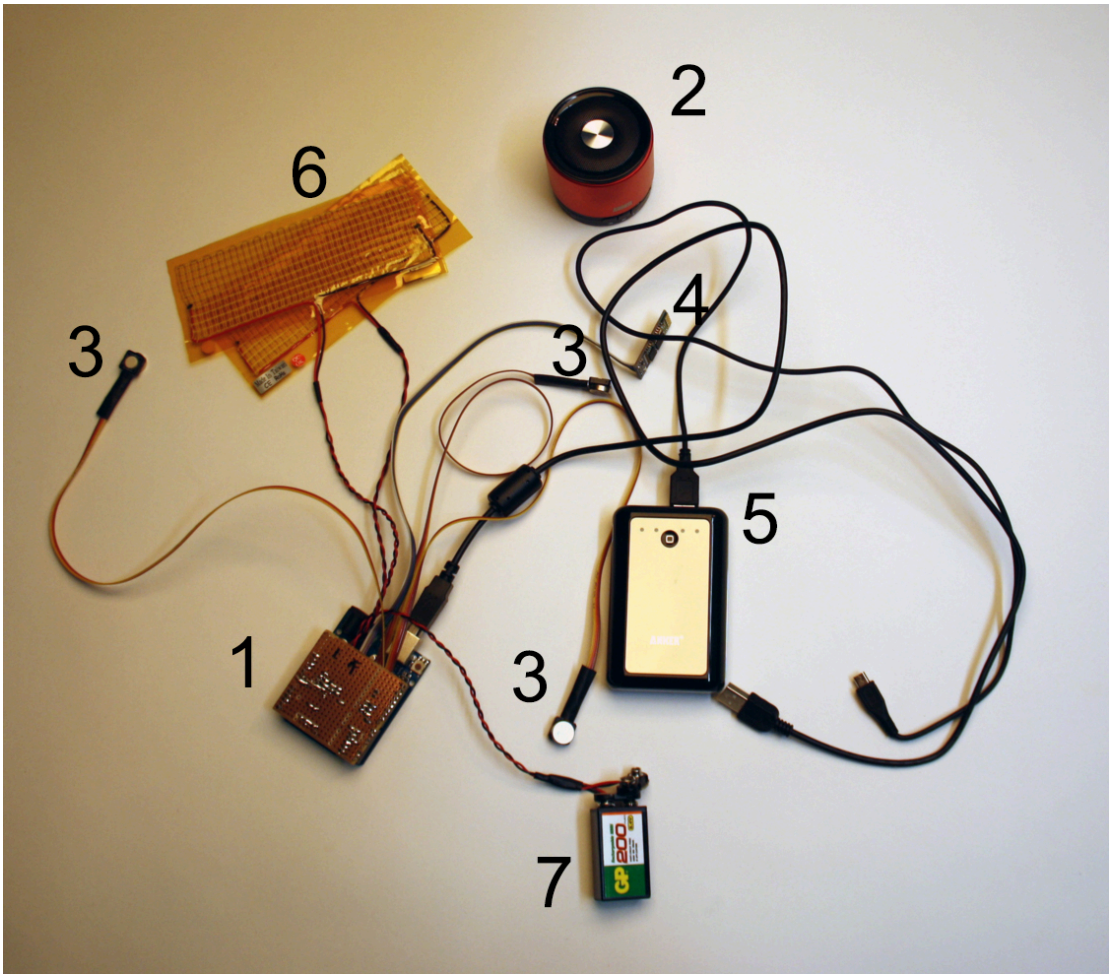

Figure 5.27 Components of child's toy

The child's toy was Arduino-enabled, and contained various sensors, such as a Bluetooth adapter (4) and a heat pad (6). These components were connected to an Arduino (UNO R3) microprocessor (1), which controls them. In addition to the Arduino components, the toy also contained a separate wireless Bluetooth speaker (2), which had been paired with the phone. A Li-ion battery (rechargeable) (7), was concealed from the user within the toy and

this powered the heat pad (6), while a rechargeable Anker Astro 2 8400mAh external battery pack (5) was used to power the Arduino unit and Bluetooth speaker (see Figure 5.27). The toy also contained push buttons (with vibration actuators) for tactile feedback when pressed (3).

Radio-Frequency identification (RFID) was considered as well as Near Field Communication (NFC) to connect the phone and the Arduino unit; however, after investigating both technologies it was decided that they were perhaps too 'power hungry' and complex (at the time of the production of the prototypes), so low power Bluetooth was used instead (Clelland, 2013).

5.5.2.2 Mobile Phone

The Samsung Galaxy Beam (used as the child's phone) offered a built-in projector for the Skype call as well as an internal Android-based operating system. This was beneficial as one 'computer' (the smartphone) controlled all interactions as well as storing and transmitting data to the parent's device through the Trace application and remote server. Thus, whilst the child's communication object required a 'buffer' (the Samsung Galaxy Beam mobile device) to transmit and receive all information, it could be housed safely and securely within the child's toy. The child had to squeeze the toy to create the desired reaction and interaction, meaning the interaction was purposeful so accidental interactions should have been reduced. The child would press the push button on the toy's hand, which offered haptic feedback through the vibrating motor, so that the child would know that the button was pressed, and their message was therefore sent. The message was then sent to the Arduino unit, which transmitted it to the child's phone (embedded within the toy) through low power Bluetooth, which then sent a push notification to the app on the parent's phone to alert them that they had a new interaction.

5.5.2.3 Software

The design of the parent's app was again based around drawings and colour schemes chosen by the families during the workshops (Figure 5.28).

The Trace App is an Adobe Air application, as per the recommendation from the computer programmer and app developer who was employed to design the Trace App (Clelland, 2013). The Adobe Air application was used as it had the capability to run on both iOS and Android devices and the parents would use their own devices for testing, with the Trace App downloaded onto them, for usability and practicality issues (they understood how to use them and always had their own phone with them).

Figure 5.28 Example of login screen to run child's app

The same application ran on the parent and the child handsets. To use the application the parent had to register/sign in to their account when the application started up (Figure 5.28). The application then entered 'child' or 'parent' mode depending on which account that had

logged in. The child's handset had to be signed into a valid Skype account with 'auto-accept calls from contacts' enabled, as this allowed the child's toy to place an outgoing call (to the pre-determined parent) without the child directly interacting with the phone itself. This method of calling through Skype is secure since the list of account contacts can be vetted and is set up by the parents (Clelland, 2013).

In 'child' mode, the application will be connected to the Arduino device (within the toy) via a Bluetooth connection. Once the connection was established the Bluetooth connection is kept open during the session (the length of time it is played with). Communication between the Arduino unit was bi-directional as messages could be sent from one device to the other. When the child pressed the corresponding happy/sad button on the toy, the Arduino unit sent a message to the phone, the phone then sent a message to the server. When the server received the message, it sent a push notification or SMS to the parent's device. The child's phone periodically pushed its location to the server (every sixty seconds) so that the parents could trace the child's toy's whereabouts by using their app. This was a safety feature the parents were keen to have so they could have 'piece of mind', knowing that their children (the child's toy) was where they were supposed to be and that they were safe, especially if they (the children) were sending numerous sad messages (Parents, 2013).

Figure 5.29 Screenshots of the parent's app

In ‘parent’ mode, the application allows parents to view emotion messages that have been sent by the child (Figure 5.29). The parents can send a ‘secret message’ to the children; this secret message will switch on the heat pad on the toy, revealing a pre-determined chosen message to appear as if by magic, when the thermochromic ink (pre-printed onto the toy) vanishes from the toy’s middle, revealing the ‘secret message’ underneath the printed panel (Figure 5.30).

The parents can receive a Skype call from the phone inside the child's toy. The parent is finally able to view the most recent location information for the child’s phone to monitor their child’s location.

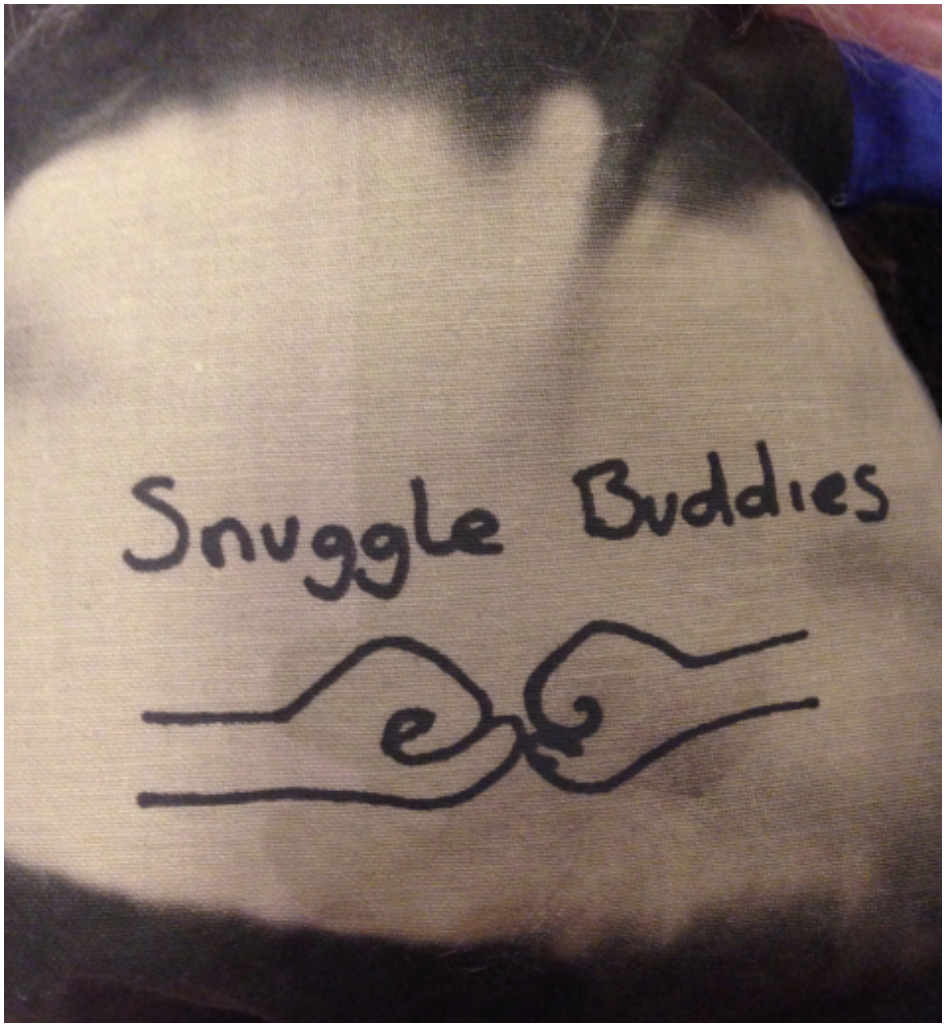

Figure 5.30 Close up of Parent 1’s drawing (secret message) on Child A’s toy

5.6 User Testing

The user testing phase happened with three families (family A, family B and family C) over a testing period of three days (Figure 31).

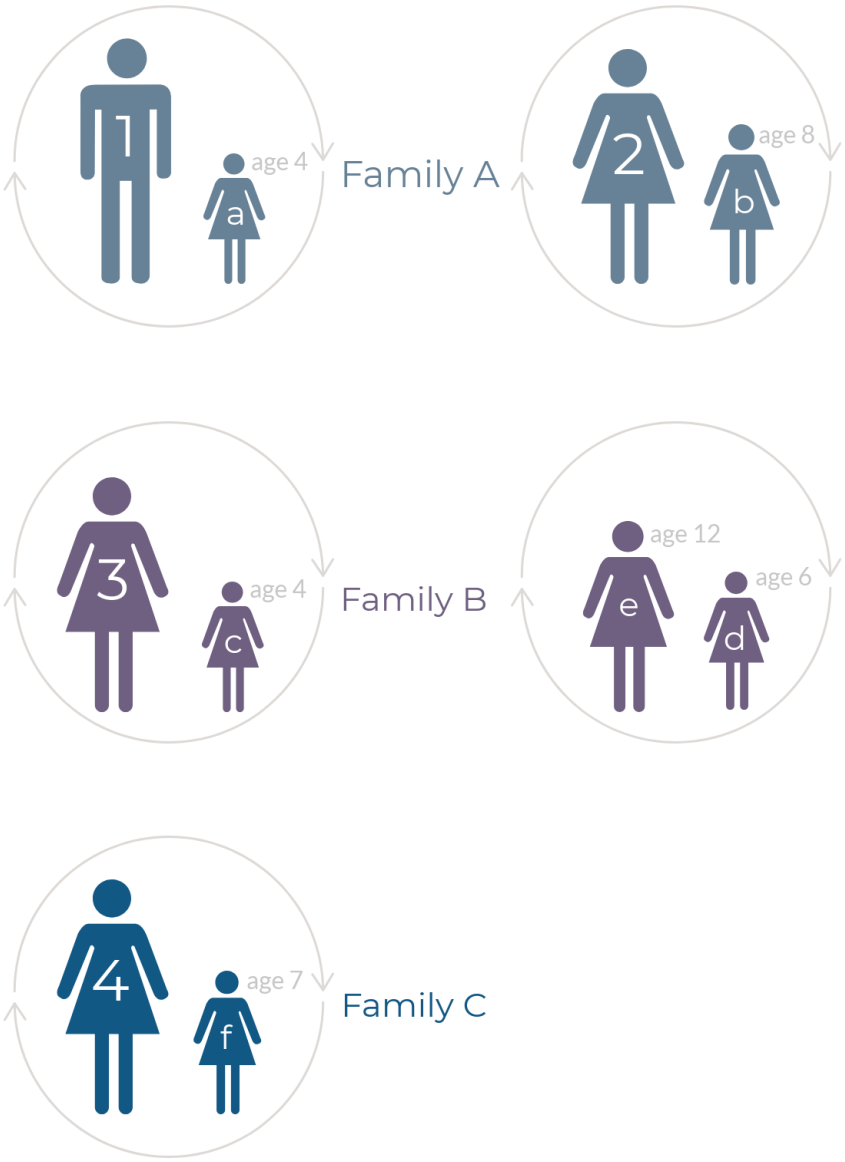

Figure 5.31 The composition of the three families who took part in the Trace Project

Table 5.5 Family Participants and Separation

Family	A	B	C
Type of separation	Work Commitments	Child Illness	Divorce
Adult(s) taking part	2	1	1
Children taking part	2	3	1

Table 5.5 Family participants and separation

Table 5.5 shows who took part from the three participant families and the types of separation they faced. All the children from each family and four out of the seven adults were included in the user testing phase for the Trace Communication System.

The three-day testing period was shorter than desired, but the researcher did not want to become present in everyday family life, disrupting the daily interactions and behaviours of the families, to troubleshoot technical issues, such as charging the key components housed within the toy(s) and maintaining the system's connectivity (pairing speaker and phone after charging).

Due to the cost of the technology (key components) within the toys, there were six toys but only two sets of components. This meant that only one family could have the Trace Communication System at a time for testing.

The children had the option to keep their toys at the end of the user testing phase. It was explained to them though, through the book and postcards, that the 'magic' of the toy would not remain (key components) but they would still have their toy to play with and love. Three out of the five children who tested toys wished to keep their no longer

functioning communication object (Children A, C and D). This may have been due to their ages as these were the three youngest children in the study (aged four and six years old). What is clear is that the children who wished to keep their toys had been actively engaged with them throughout the user testing. So, although their communication objects no longer worked, they had achieved several levels of co-presence through their toys. They felt comforted by them, and through them they felt closer to their parents (see Section 5.7.1.1, *Families' Joy*).

The research data that was captured from the toys and apps (timings, emotions, response times) was analysed alongside participants' diaries and follow-up interviews.

Table 5.6 is an example table of a data logs showing the interactions from parents and children and the timings of these. Data logs of each family's direct interactions with the Trace Communication System can be found in Appendix 4.6.

Table 5.6 Example Table

		Interaction	*Time*
Parent's interactions	1	Secret Message	7.01pm
	2	Audio Message	7.04pm
	3	Tracking	

		Interaction	*Time*
Child's interactions	1	Happy	7.39pm
	2	Sad	6.57pm, 7.02pm
	3	Skype Call	7.10pm

Table 5.6 Example data log showing interactions from parents and children and the timings of these

The following section, 5.7 *Analysis*, details the interactions and responses, which took place over a three-day testing period with each family. The testing highlighted some key points and considerations with regard to timings and automatic responses, depending on the child's age and understanding of the separation types, as well as the appropriateness of the communication objects and general aesthetics.

The analysis section begins detailing how the data was collected, categorised and analysed and how coding the coding scheme was developed.

5.7 Analysis

The analysis in this enquiry is qualitative. It draws upon the requisite to understand the families' communication needs and experiences in daily life set out by the Research Questions '*Can wearables and smart textiles aid intimacy within family communication systems?', and 'What is the role of co-design in the understanding and creation of such a system?*'. Qualitative enquiry lets us understand how specific experiences are "*lived*", as well as specific circumstances that lead to the raw data (Haddon, 2011, p314).

Categories of Data:

Four categories of data (*Understanding*, *Activities*, *Interaction*, and *Reflection*), were collected throughout the Trace project. *Thematic Analysis* was employed (section 3.3.2.5.1) to understand group and sort the data into *codes* and *sub-codes* from the four initial categories. This meant the information could be clearly sorted at each stage of analysis, resulting in further understanding of the raw data at each iteration (coding cycles). This way of analysis allowed for the validation or dismissing of the raw data collected throughout the Trace project. This approach allowed for more focussed results and research claims to be derived from the analysis of findings within the Trace project (Table 5.7).

The data collection methods that were used at each of the five main stages of the Trace project are shown in table 5.7.

Table 5.7 Data Collection methods used in the Trace project

When	What	Method
Start of Trace Project	Introductory Interview	Interview Guide
Co-design Workshop 1	Prototyping Conversational Interview	Generative Toolkit: worksheets, drawing, making Interview Guide / Informal Conversational Interviews
Co-design Workshop 2	Prototyping Conversational Interview	Generative Toolkit: worksheets, drawing Interview Guide / Informal Conversational Interviews
User-testing	Testing the Final Trace Communication System	User Experience Testing Diary Studies
End of Trace Project	Debriefing Interview	Interview Guide / Informal Conversational Interviews

Table 5.7 Data Collection methods used in the Trace project

Table 5.8 Families 'sayings'

What	Category	Code
Introductory Interview	Understanding	Individual and family needs Communications Objects and Systems
Co-Design Workshops/ Conversational Interview	Activities	Making Sayings Engagement
Testing the Final Trace Communication System	Interaction	Preference (time, object, communication) Curiosity Engagement Enabling connections
Debriefing Interview	Reflections	Intimacy Positives Negatives Suggestions (objects and system) Suggestions (process)

Table 5.8 Data collected from the families' *sayings* at each key stage of the Trace project

The data collected from the families' sayings were coded into four main categories 1. Understanding, 2. Activities, 3. Interaction and 4. Reflections (table 5.8). These categories were broken down into codes and sub-codes through two coding cycles. The *First Stage* assigns codes to "*data chunks*", and the second stage refines data and sorts in to more concentrated categories (Miles *et al*. 2014, p 73). The full framework of the coding scheme can be found in Appendix 4.10 Analysis.

Thematic Analysis:

Thematic Analysis was used to sort and validate the data collected from the participant families as set out in Chapter 3, Section 3.3.2.5.

Figure 5.32 Data sets produced through the user testing phase of Trace Communication System

The user testing of the Trace Communication System actively generated two of the three data streams used for data analysis:

- ***Interaction Data*** (user testing of the Trace Communication System) – how much the objects were used and what types (modes) of communications were used (Section 5.6 *User Testing* and Appendix 4.6).

- ***Self-Reporting*** (diary studies) – where the families kept diaries, detailing thoughts, feelings and technical issues (if any) after each interaction (Section 5.6 *User Testing* and Appendix 4.7.4).

The third data stream is:

- ***Interviews*** – conducted after the user testing and first stage of data analysis, to confirm or clarify data sets.

Understanding the families' 'doings', 'sayings' and 'relatings', through comparing three alternative data sources, demonstrates the importance of looking at numerous data sets to verify findings. For example: some of the sad messages that were sent were due to:

1. the child playing with the system to see what would happen,
2. in error, or
3. they may not have understood the context.

It is important to acknowledge, in these instances, that sad messages did not correlate to the child feeling sad. This information could have been lost or taken at face value, and the assumption made that the child was sad, if only the interaction data had been considered, and the other data sources had not been collected (diary studies and interviews).

To further emphasise this point, when looking through the raw data collected from the parent's phone on the interactions with Child A, Child A was unhappy seven times over the course of the three-day period. If only the data logs of interactions had been considered, it would have been assumed that the child was sad at these points. However, when reading through the diary entries and analysing the follow-up interviews, it was confirmed that three of these unhappy messages were when the child was testing the toy, one was made in error and one was due to the child not being allowed the treat they wanted. Only two of the sad emotions were directed at the parent for their absence. It is these genuine sad feelings and the situations they stem from that are most important to the parents and what the families wanted the Trace Communication System to help monitor and alleviate.

As previously mentioned interviews were the main source of data collection for understanding the families, and their needs, wants and desires in relation to their remote communications.

Thematic Analysis was used to understand and group the families points of views into codes and sub-codes, within the four original categories understanding, activities, interaction and reflection.

Coding in such a way provides an overview the data, providing road map of information that is important when answering the research's aims and objectives and offered the opportunity for further categorisation and a Coding Scheme was developed.

The Analysis of the data generated from the introductory interviews, co-design workshop interviews, user-testing and debriefing interviews all followed an iterative two stage coding process:

- **First Stage**: assigns codes to "*data chunks*".

  (Miles *et al*. 2014, p 73)

- **Second Stage**: refines data and sorts further into concentrated categories (thematic analysis).

Table 5.9 shows a condensed version of the families' sayings coding scheme, giving an overview of the main categories derived from the *first stage* of analysis and the sub-codes which came from the refinement of the information within the *second stage* of the analysis. The full framework of the coding scheme can be found in Appendix 4.10.

Developing the Coding Scheme:

First Stage Coding:

Structural coding was used due to the varying data streams drawn from the numerous interviews (both Informal Conversational Interviews and the Interview Guide Style) with the families. Through this method of data analysis, information was easily sorted and searchable into, and under key categories, themes and sub-themes (see Appendix 4.10.5 for the full framework of the coding scheme). It offered a road map of themes that were important in answering the research questions and presented the opportunity for further categorisation of the initial groupings and first stage codes (Saldaña, 2015, p49).

It was important to give precedence to the participants sayings while remaining objective throughout. Thus, the transcripts of the families' sayings were sorted and coded into recurring categories.

The four categories that were identified in the first stage of the coding process were:

- Understanding
- Activities
- Interaction
- Reflection

Second Stage Coding:

Second stage coding looks at the first stage coding and sorts it into more meaningful categories or sub themes of the original themes (*pattern coding* or *thematic analysis*). This helps to sort and organise the first stage data into useable information surrounding the themes and sub themes (Saldaña, 2015, p49).

The Coding Scheme:

Table 5.9 provides a condensed view of the coding scheme, with the full framework available in Appendix 4.10 detailing all of the categories, codes, sub-codes and examples of the families sayings. Each of the coding categories, codes and sub-codes were captured showing the parents as well as the children's perspectives. The coding scheme outlines the primary results within the families' sayings, answering the research's aims and objectives and contributing to the research's key findings.

Table 5.9 Condensed Coding Scheme

Categories	Codes
Category 1 Understanding	Individual and family needs Communications Objects and Systems
Category 2 Activities	Making Sayings Engagement
Category 3 Interaction	Preference (time, object, communication) Curiosity Engagement Enabling connections
Category 4 Reflection	Intimacy Positives Negatives Suggestions (objects and system) Suggestions (process)

Table 5.9 Condensed coding scheme

Category 1 Understanding:

Table 5.10 Category 1 Understanding Coding Scheme

Categories	*Codes*	*Sub-Codes*
Category 1 Understanding	Individual and family needs	- Instant communication - Control for children - Easy to use / understand - Personalised Information - Non-screen based - Easily adopted / supported by existing object(s)
	Current Communication Methods	- Mobile Phone / Landline (Audio) - Smart Phone / Tablet / Laptop using Skype (Audio and Visual) - Text message (Over age 10 with own mobile device)
	Objects and Systems	- Personalised - Easily adopted - Easy to use - Appropriate

Table 5.10 Category 1 Understanding Coding Scheme

Category 1 *Understanding*, along with the initial coding schemes for category 1, *Individual and family needs*, *Current Communication Methods* and *Objects and Systems* were developed through families sayings at the introductory interviews. This category was added to through the *second stage* coding process, applying thematic analysis to further sort and code

the families' sayings into sub-codes (table 5.10). The full coding scheme for Category 1, showing examples of the families' sayings can be found in Appendix 4.10.5.

Category 2 Activities:

Table 5.11 Category 2 Activities Coding Scheme

Categories	*Codes*	*Sub-Codes*
Category 2 Activities	Making	- Objects - Personalised - Systems
	Sayings	- Objects - Non-screen based for children - Personalisation - Communications
	Engagement	- Usefulness - Appropriate - Easy to understand

Table 5.11 Category 2 Activities Coding Scheme

Category 2 *Activities*, along with the initial coding schemes for category 2, *Making*, *Sayings* and *Engagement* were developed through families' sayings captured within the co-design workshops through conversational interviews and discussion during the making and prototyping activities of the generative toolkits. This category was added to through the *second stage* coding process, applying thematic analysis to further sort and code the families' sayings into sub-codes (table 5.11). The full coding scheme for Category 2, showing examples of the families' sayings can be found in Appendix 4.10.5.

Category 3 Interaction:

Table 5.12 Category 3 Interaction Coding Scheme

Categories	*Codes*	*Sub-Codes*
Category 3 interaction	Preference (time, object, communication)	- Time delay (response time) - Objects - Personalisation
	Curiosity	- Play - Reaction
	Engagement	- Usefulness - Acceptance - Appropriate
	Enabling Connections	- Location sensing - Understanding basic emotions - Direct contact - Secret Message - Discreet communication

Table 5.12 Category 3 Interaction Coding Scheme

Category 3 *Interaction,* along with the initial coding schemes for category 3, *Preference, Curiosity, Engagement* and *Enabling Connections* were developed through families' sayings captured throughout the user-testing phase of the project. This was done through the raw data collected from the toy (see appendix 4.6 data logs, for interaction tables), diary studies (collecting immediate reactions to using the system) and through conversational interviews and discussion at the de-briefing interview at the end of the Trace Project. This category was added to through the *second stage* coding process, applying thematic analysis to further sort and code the families' interactions into sub-codes (table 5.12). The full coding scheme for Category 2, showing examples of the families' sayings can be found in Appendix 4.10.

Category 4 Reflection:

Table 5.13 Category 4 Reflection Coding Scheme

Categories	*Codes*	*Sub-Codes*
Category 4 Reflection	Intimacy	- Commitment - Affective Intimacy - Cognitive Intimacy - Mutuality
	Positives	- Instant communication - Time delay (response time) - Control for children - Easy to use / understand - Personalisation
	Negatives	- Time delay (response time) - Personalisation
	Suggestions (objects and system)	- Secret message - Audio message - Tracing - Happy/Sad message - Skype call - Using different communication options for different reasons / emotions / information / connection
	Suggestions (process)	- Introductory Interviews - Workshops - User testing - De-briefing Interviews

Table 5.13 Category 4 Reflection Coding Scheme

Category 4 *Reflection*, along with the initial coding schemes for category 4, *Positives, Negatives*, *Suggestions (objects and system)*, and *Suggestions (process)*, were developed through families' sayings captured throughout the user-testing phase of the project. This was done through the raw data collected from the toy (see appendix 4.6 data logs, for interaction tables), diary studies (collecting immediate reactions to using the system) and through conversational interviews and discussion at the de-briefing interview at the end of the Trace Project. This category was added to through the *second stage* coding process, applying thematic analysis to further sort and code the families' reflections into sub-codes (table 5.13). The full coding scheme for Category 2, showing examples of the families' reflections can be found in Appendix 4.10.

5.7.1 Findings

The analysis of the families' 'doings', 'sayings' and 'relatings', were developed from the codes and sub-codes drawn from the thematic analysis coding process. They were translated into the main findings. The main themes identified for the findings were ***families joy***, ***frustrations***, ***worries*** and ***recommendations,*** and are detailed as follows:

Families' Joy (Section 5.7.1.1)

- ***Co-presence (virtual, proxy and imagined)***: through using the Trace Communication System, predominantly the toy for the child.
- ***Play:*** using features such as Skype calling or sending messages as a method of play. Calling and hanging up, 'bugging' each other with constant silly messages.
- ***Magic:*** a sense of wonder and delight about the secret message function.
- ***Direct contact:*** between parent and child (not through a proxy – mother/father/grandparent).
- ***Tracing:*** location sensing of the child's toy.
- ***Communication log:*** historical timeline of communications saved automatically on parent's app.

Families' Frustrations (Section 5.7.1.2)

- ***Time lag:*** messages were not always picked up straight away.
- ***Aesthetics:*** child's object (size, look).
- ***Clarity of emotions***
- ***Usability and Charging***

Families' Worries (Section 5.7.1.3)

- ***Safety:*** technology, information.

Families' recommendations (Section 5.7.1.4)

- ***Wider range of emotions***
- ***Interactions:*** giving the children the opportunity to send audio messages.
- ***Object choice:*** for all ages and stages of children.
- ***Personalisation:*** more personalisation.
- ***Time lag:*** contingency to stop children feeling rejected or ignored when messages cannot be picked up or answered straight away.

5.7.1.1 Families' Joy

Co-presence: Virtual, proxy and imagined co-presence were observed by the families throughout the user testing of the Trace Communication System. Children experienced virtual co-presence, through the Skype call feature. Proxy co-presence was created through the audio and secret messages parents sent to their children. While imagined, co-presence was experienced by the three younger children (Children A, C and D) after the technology had been removed, through everyday play with their toys. Examples of these are found further in Section 5.7.1.1 *Families' Joy*, under subheadings '*play*', '*magic*' and '*direct contact*'.

Play: Children were observed playing games with their objects, such as continuously Skyping then hanging up to "*annoy*" or "*have fun*" with their parents

(Child C and Child D, 2014). Family B especially used this function often with both Child C and Child D, using the Skype feature to call say something silly and hang up (see Appendix 4.6.2, *Family B*'s data logs). Family B stated they would have liked the Skype feature to go both ways, enabling the parent and older sibling (Child E) to return the call, but improvised by sending silly audio messages or secret messages as a reply. Using the Skype feature in this manner was not expected, but outlines the children's need to have fun and play in their communications.

Magic: The secret message function of the toy was the most favoured feature with all the families. Having a special message printed on the toy's stomach that parents could reveal by sending a secret message, caused lots of excitement within each family with Child A stating:

> "*Pinkie* (pink monster toy) *let me talk to Daddy, his magic has run out now and is letting other children like me and my sister speak, but if I squeeze him tight enough, our 'snuggle buddies' fist pump is there… Daddy is thinking about me*".

Even when the technology was removed (after user testing), the children who kept their toys discussed the 'magical' properties their toys still embodied. This was due to the mid-section of the toy being printed with thermochromic ink, so when the child hugged the toy tightly enough, their body heat caused the reaction to occur revealing the 'secret message'. The children still sought comfort and felt connected to their parents through their toys, through proxy co-presence, after the user testing phase was over, by cuddling their toys.

Direct Contact: Virtual and proxy co-presence were observed by the families when using the Trace Communication System. This allowed both parent and child's needs to be met, through direct contact with one another (e.g., Family A, Child A and Parent 1, Day 3 at bedtime, see Appendix 4.6.1). Parent 1 had sent an audio message to Child A at 6.43pm saying that they could not Skype that night as they were travelling home. Child A replied with a sad message at 6.45pm, disappointed they would miss their daily 'ritual' of a bedtime chat (which took place either in

person, if the parent was at home, or over the phone, if the parent was away). Occasionally when Parent 1 was travelling this 'bedtime chat' had to be postponed with the other Parent (2) passing on the information to the child. However, the Trace Communication System allowed Child A direct contact with Parent 1, communicating their feelings on the missed bedtime routine. In turn, the parent was then able to respond using a quick audio message (6.49pm) along with a secret message (6.52pm) of reassurance, reminding them that they would be together in the morning. Subsequently, the child replied with a happy message at 6.54pm, and later discussion (follow-up interviews) revealed that this had "*alleviated some of the* [parent's] *guilt for being away*" (Parent 1, 2014). This was due to Parent 1 knowing that their child had gone to bed having had some direct interaction with them, rather than through the other parent. This was also found to relieve general tension at home, if the 'at home parent' (Parent 2) did not have to pass on messages from the 'distant parent' (Parent 1) and manage the child's (Child A's) reactions of sadness and disappointment.

Virtual co-presence was also observed through the Trace Communication System in Family A, Parent 2 and Child B (see Appendix 4.6.2). On day one at 7.58pm, Child B sent a sad message in response to Parent 2's audio message stating that she would be late home due to work commitments. The sad feelings did not last long, however, and child B sent a happy message (8.09pm) to Parent 2 after their Skype call at 8.02pm. During the follow-up interviews Parent 2 said:

> "*The fact that ****** was able to call me herself on Skype and complain a bit that I was working later than I had promised seemed to lift her mood and we were able to have a quick chat on my break… ****** then seemed pretty happy to go to bed and sent a happy message after we had finished our talk… this was great as I didn't have to worry about her sulking*" (Parent 2, 2014).

Tracing: Child F's sad interaction from day 3 (4.03pm) was a result of falling out with a friend at school (see Appendix 4.6.3 for Family C's data log of interactions). Parent

4 sent an audio message for reassurance (4.05pm), then checked on Child F's whereabouts (4.07pm). Parent 4 stated later through the follow-up interview that:

> "*It was reassuring to know* ****** *was at home* [through tracing the toy's whereabouts], *and a quick phone call to Granny to see what had happened put my mind at rest*" (Parent 4, 2014).

Communication Log: Parents enjoyed the communication log, stored within their app. They could scroll through interactions in a communication timeline. Parent 1 stated:

> "*It's like a Facebook timeline, or Twitter feed, but cooler, as it shows all the messages we have sent each other… it was cool to see how much I was able to contact* ***** *and her me by using the* [Trace communication] *system*" (Parent 1, 2014).

Longer testing periods may show up patterns of emotions (happy, sad), which could help parents manage a child's anxiety or sadness if sad messages were always sent around certain times of the day or before/after certain events, i.e., parent leaving, switchover between two family homes, doctor's appointment.

5.7.1.2 Families' Frustrations

Time lag: Child A's sad interaction on day 2 at 5.42pm was a reaction to Parent 1 failing to respond to their happy messages at 4.15 and 4.17. This is verified through the corresponding diary that shows why emotions had changed at this point (from happy to sad twenty-five minutes later) (see Appendix 4.6.1), with child A remembering in later discussion, within the follow up interview that she had felt that Parent 1 was "*ignoring*" her (Child A, 2013). Frustration had set in after no contact was made even after she had eaten her evening meal, resulting in a sad message being sent that echoed her emotional state. This verification of the data through capturing alternate data sets shows why a sad message was sent, and that the child did indeed feel anxious and ignored.

Even though Child B did not interact as much with her communication object as her sibling did (Child A), the family agreed that it was still beneficial and a refined communication object would be welcomed. Child B stated:

> "*If I had a better object that would be great, I liked being able to talk to Mummy… my toy is ugly and I want something cool*" (see Appendix 4.6.1, follow-up interview with family A).

Aesthetics: Child B's sad interaction on day 1 at 11.37am (Appendix 4.6.1) was in response to the look of her communication object. Child B was not fully engaged when using the toy, even though she had been very vocal and enthusiastic during the co-design workshops. Upon receiving her toy, Child B was disappointed at the lack of likeness to her own drawing and didn't recognise it as 'her toy'. The rejection was a significant revelation, as acceptance of the communication system was vitally important for intimate communications to take place. While Child B somewhat enjoyed communicating with her parent through using her toy, she was never fully committed to it, due to the lack of attachment she had felt stemming from her initial disappointment in its appearance. Child B (2014) stated in the user testing:

> "*It doesn't look like my drawing*" (Child B, 2014).

This point was reiterated in the follow-up interview when she affirmed that she was:

> "*disappointed, and sad*" with her toy, as it wasn't what she had imagined it would be (Child B, 2014).

Child F (2014) was also disappointed with her toy's aesthetic, stating:

> "*Did I draw that? My drawings are much better usually*".

Clarity of Emotions: During Child's F's interactions with Parent 4 sometimes sad messages were sent, not because the child was in distress, but because the child did

not like a request from their parents. Parent 4 had sent an audio message, on day 1, to child F at 5.23pm saying "*remember to eat your broccoli tonight not just your carrots, sweet pea, love you and we shall chat before bedtime*". The child's response was to the broccoli part as she is not fond of this vegetable. The clarity of emotions links to a wider range of emotions available for the children to use (Section 5.6.1.4, *Families' Recommendations*).

Usability and Charging: Usability and charging of the Trace Communication System was an issue for the participant families, as they expressed their frustration that they could only keep the system for three days, stating:

> "*It would have been useful to keep the toys longer, to see if it really did make a difference, it was frustrating that they ran out of power [the toys] and that they were too difficult to charge without your help [researcher]*" (Parent 4, 2014).

> "*Charging was the main problem, that we couldn't do this ourselves due to the toy's complicated setup, or we would have kept it much longer [Trace Communication System], ***** was disappointed when the system was taken away, as she really enjoyed playing with it to talk to her dad… but being able to keep her toy helped, and she really enjoyed the postcards, they were a nice idea, it helped her to understand that other little boys and girls were sometimes missing their parents and wanted to try Trace*" (Parent 2, 2014).

5.7.1.3 Families' Worries

Safety: Families worried about the security of their interactions and the messages being sent; a particular worry was the tracking of the child's toy, even though this was a feature the parents pushed for and did value, they were concerned that people could hack the information and locate their children through their toy. Parent 2 asked:

"*How safe is the information?... I mean can others easily see ****'s* whereabouts? That's my issue with features like Facebook check-ins* [a service that allows you to 'check-in' to places and 'tag' others at the location], *I worry when they get older and use social media that they will share this type of information about their whereabouts, and you never know who could be looking at that or following them… it's a real worry to me*" (Parent 2, 2014).

"*Who else has access to our information*?" (Parent 4, 2014).

5.7.1.4 Families' recommendations

Wider range of Emotions: A wider range of emotions was requested by the older children (Child B, Child E and Child F), as they felt simple happy or sad messages did not cover the wide range of emotions they experienced, stating:

> "*Sometimes I feel silly, annoyed or angry, smileys* [emoticons, used in text messages and on social media] *give you more ways of telling your parents how you feel*" (Child E, 2014).

> *"I want to send Mummy the kissy smiley* [Kiss emoticon]" (Child B, 2014).

> "*I want to send the boke face* [green sick emoticon] *when I am having school dinners*" (Child F, 2014).

However, some of the parents stated that these were enough and any more would add too much complexity to the toys, especially for their younger children.

Interactions: More interactions were sought frm both parents and children with Parent 3 (2014) stating:

> "*It would be wonderful to have an audio message option for the toy to record and send messages, so ****** could send me messages as well as receiving them*" (Parent 3, 2014).

This feature seemed to be a popular request with all families mentioning this through feedback, either through the follow-up interviews or in their diaries. Child D stated:

> "*I want to send silly messages to my sister, she sends them to me, I can't do that so I Skype her and then hang up quickly"* (Child D, 2014) [Smiles, laughter and lots of giggling follows].

While Parent 2 said:

> *"I think* ******* [Child B] *would have used it more if she could have sent audio messages to me and not just the basic happy or sad ones, that worked well for* ****** [Child A] *due to her age, but you know, I think for the older ones something more advanced is maybe needed*?" (Parent 2, 2014).

This also offered further possible reasons why the older children (aged 7 and 8) did not engage as well with the communication system. The aesthetics were an issue but, also, it seems that perhaps they were looking for more complex communications. Further testing with a wider range of selective features as well as longer testing times would be needed to prove or dispel this thinking.

Child E (12 years old) enjoyed using the parent's app to connect to her younger sibling (Child D), as this fitted in with her ideals and aesthetics regarding how she wanted to communicate. She stated, however, that she might have liked to have had some of the features and interactions offered by the younger child's toy:

> "*It woulda been quite neat to be able to send the happy or sad messages, I would have liked more emotions though, like the emoticons on my phone, the Skype projection is pretty cool too, it was a bit annoying I couldn't Skype xxxxxx… it was funny to send the audio messages… it woulda been good if xxxxxx coulda sent these back to me too instead of just Skyping as she could just do that in our bedroom not anywhere else*" (Child E, 2014).

It was noted through the user testing that having an option for the children to record and send messages would have been very beneficial as Parent 4 was left wondering why her child was sad:

> *"***** sent me unhappy messages but I had no idea why she was sad, I couldn't Skype her and she couldn't send me messages"* (Parent 4, 2014).

Object Choice: Two of the older children (Child B and Child E) did not engage with their toys due to the aesthetic and size. Child F wanted the features that her siblings had in their communication objects but did not want a 'child's toy'. All the families felt that while the toys worked well for the younger children (aged four and six), the older ones (seven, eight and twelve) needed alternative objects to suit their communication needs. The parents of Child B and Child E maintained their original view that a mobile device was not suitable due to the cost and safety issues attached to a child owning their own device. They were interested to see what future research could offer young people and pre-teens (Weber and Dixon, 2007). The oldest child (twelve) had her own mobile phone and used the app to communicate with her younger sibling.

Personalisation: The need for function and 'enchantment', or a desirable aesthetic for the user, was found to be paramount during the Trace Project. It determined the level of engagement and intimacy gained, by both parent and child, from using their communication objects (Figure 5.33). Whilst the communication objects (toys) themselves were not classically beautiful, in some cases they were rather ugly and seemingly unappealing, they held a desired aesthetic for the children and families involved. The appeal came from the personalised nature of the way in which they were created from drawings, conversations, needs, wants, and wishes of the families, especially the children in relation to the toy – the child's communication object. Tailoring the objects in this manner instilled in each toy a characteristic desirable to those who helped create them, while to others there was no wish to

have or use the toys. Children aged from four to six engaged extremely well and interacted with the toys much more than the older seven to nine-year olds.

Time Lag: Contingency for time lags is an important consideration in the design of the communication objects. It is not always possible for the parent to respond to the child immediately as they may be in a work meeting, driving or in a situation where their mobile device needs to be switched off. It is important to consider then if automatic responses or other features can be included within the communication system (i.e., colour change when parents are available). These types of contingencies intend to prevent unnecessary frustration, feelings of rejection and increased distance between parent and child occurring, when synchronous communications are impossible.

Possible solutions for time lags would be to have a recorded message from the parent that would be an automated response to the child when they send a message or reach out to their parent. For example, when the parent is not able to reply straight away themselves, the Trace System would reassure the child that the parent is unable to respond immediately due to whatever reason, i.e., '*Daddy cannot reply right now sweet pea as I am on an aeroplane, but I will reply as soon as I land, remember Daddy loves you very much'*. A message to this effect may be all the child needs to hear to feel connected and secure. However, this is pure conjecture and would need further validation via tests with these time delay 'safeguards' in place to test if this would be a valid solution to asynchronous communications and time delays in responding.

Key Learning

Engagement with the Trace Communication System: The only time a child was not fully engaged (Child B, 8 years old) was to do with the toy itself. Upon receiving her toy, she was disappointed at the likeness to her own drawing and didn't recognise it as 'her toy'. The rejection was a significant revelation, as acceptance and

a fondness for the communication object was vital to generate the required intimacy and connection for successful communication, through a communication system such as the Trace Communication System. While Child B somewhat enjoyed communicating with her mother through using her toy, interactions were reduced, due to the lack of attachment she had to her object, stemming from her initial disappointment in its appearance.

The researcher had presumed that making toys from the children's drawings and allowing them to choose the fabrics and colours was enough to offer personalisation and facilitate the required connection to the toy. However, in future research it is acknowledged that further integration is needed. Questions arose surrounding children's acceptance and connection to their communication objects, how this might increase if they helped with the sewing process, or alternatively the actual drawings were digitally printed onto the fabric and sewn up. These approaches were not possible within the budget or with the technology available at the time of creation (2013/2014). The toys created were large, around 70cm tall (Figure 5.33), and worked well for pre-school children and children up to the age of six, but above the age of six the engagement with the toys from the two older children (aged seven and eight) diminished considerably. Through talking with the children and their parents it was confirmed by the older children that the toys were too large and did not fit in with the image they had in their head about what their drawings would look like when made into a fully functioning communication object. They were "*disappointed*" (Child B) and "*It doesn't look like my drawing*" (Child F) with Child B stating "*Did I draw that? My drawings are much better usually*."

These feelings of initial disconnection with an object and steps to avoid the feelings of disappointment associated will be discussed further in Section 5.17, *Discussion about Observations and Results*, and Chapter 6, *Discussion, Conclusions and Future Directions*.

The 'novelty factor' must be considered and future prolonged testing would be recommended with more stable technology to ascertain if this type of technology

makes a difference in remote communication and connectedness, or if the joy, excitement and eagerness to use the communication objects were more down to the newness and novelty of the unknown. The core of this thesis study assembles the building blocks of the various ideas that were generated and demonstrating a need for intimate connection over distances between parent and child. The Trace Communication System provides the child with some ownership over their communications so they can be in control and choose when and how they would reach out to their parents and share their emotions.

Positively: Child A's reaction to her toy was a squeal of excitement and a big hug for the toy and the researcher; there were lots of smiles and she was eager to learn how it worked and to test it out. It is unknown if this reaction was down to the child's age, personality or likeness to the child's initial drawing, but user testing did demonstrate that the engagement and interactions were higher with Child A than Child B, even though they came from the same family and had the same separation issues. In looking at interviews, diary studies and levels of interaction, it is possible to observe that the level of engagement was heightened by the child's attachment to the toy as a physical object and not just what it offered in terms of communication features. However, further user testing would be required for these results to be considered conclusive. The researcher's small study, even within one family, illustrates the difference in the level of engagement and communication with an object that is valued and well received over an object that is not.

After the final user testing (through the analysis and reflection stages), it was important that the families (especially the children) were offered some sort of closure, especially those who had become attached to their communication objects and the interactions they offered. It was therefore essential to make the families aware of the fact that the Trace Communication System was not a final working product that was stable enough to be left indefinitely with them to use. Consequently, it was important to convey a meaningful reason to the children in order for them to understand why their toy (communication object) no longer had its 'magical' abilities. The children had the option to keep their toys, without the

technology inside as a reminder of the project, and this was especially important if they had become attached to their toy.

For project closure and transition stages post-testing Trace Postcards were created to ease the transition, and used as project closure for the children.

Collaborative working on a project such as this, which marries technology and craft practice through a collaborative methodology, can be problematic. This is due to the multidisciplinary process needed to utilise knowledge from alternative disciplines along with the integration of the end users within the whole research process. However, if this type of collaborative working can be executed successfully, it can offer rich results and enable future research in cross-disciplinary areas.

Figure 5.33 Trace Toy and House (User Testing)

In any project, it is important for its overall success that everyone has a clear understanding of the aims and objectives of the project. At times during the Trace Project this was hard to achieve with lots of information being shared via email when face-to-face meetings were not possible due to the external contractors (illustrator, textile designer, and programmer) having other work and family commitments. The researcher also perhaps underestimated what could be achieved with the technology on offer within the budget that was available. However, the result was six toys: five of the children's and the face of the Trace Project 'Buddy', the friendly monster, two working sets of key components, which consisted of all of the technology that ran the toys and connected to the parents, a phone application (parent's and child's) that ran on both Android and Apple devices, a children's book that explained the project to the families and how the system worked in simple/easy-to-understand terms, the Trace 'Buddy' diary to capture immediate thoughts and feelings when using the Trace Communication System, and six follow-up postcards that would offer some closure for the families after the user testing phase was over.

Co-design - Through co-design workshops and interviews with parents (2013 and 2014) and children (2013 and 2014), the communication needs of each family member and how these could be achieved were discussed. It was established through these conversations, that parents needed different information and channels to receive communications compared to what their children required (see Section 5.4.5 *Understanding the Participant Families and their Requirements*). These discussions offered an understanding about family dynamics and function and about how each individual family member interacts with technology and with each other. This allowed researchers to see what could be adapted in terms of current communications, and what simply would not work for each individual family and member (Carvahalo *et al*. 2015).

The way to uncover people's true needs and what they dream then is through generative design methods. A series of worksheets and making activities combined

with *Informal Conversational Interviews* which use general topics to direct the flow of conversation. These were implemented within a co-design workshop setting to gain full understanding of the families' sayings doings and relating's. This gave a full picture of their backgrounds, family values and communication needs.

For example, if the families did not get the opportunity to draw, make and discuss their communication issues, they would not have thought of some of the key features that were successfully implemented within the Trace communication system, like the projection, or the secret messages, which were favourite features and created a sense of closeness that only came from the families' makings. These hidden dreams or desires would be hard to uncover without a process of making. As previously mentioned, when asked a direct question, people will normally give you a direct answer, but sometimes they are not aware of what they want or need to say until they prototype it. This process of making allowed the families to jointly generate ideas, create prototypes and show examples of 'meaningful use'. This shows that by working closely with families in a mindful and attentive way makes it more likely that the resulting communication system will be seen as meaningful by the families.

5.8 Summary of Main Study – The Trace Project

The Trace Project is a novel example of how communication systems can be co-designed with families, highlighting the possibilities that disparate communication objects have as part of a unique communication system for enriching family relationships when families are separated.

Three days proved to be a valuable testing duration for the Trace Communication System, with no major technical issues arising that compromised the use of the system. Longer testing periods would be suggested in future user testing and refinement cycles of the Trace Communication System or similar family communication systems for parent and child.

The families engaged well with the Trace Communication System due to this element of fun and ease of use, alongside their previous engagement and inclusion in the design and development of the system. Engagement is an important tool when trying to get people to adopt new communication systems, as well when trying to get people to feel connected when using said system.

The excitement, wonder and playfulness that happened as a result of communicating through the toy (i.e., through the changes, messages and video calls that were facilitated by the toy) were due to the co-design process and its physical and tactile form. It is believed that offering the child a screen-based object would not have afforded the same level of engagement, fun and intimate connections as the physical object. However, this has not been fully tested and is based on other research (Agomanolis, 2008; Baym, 2010; Dalsgaard *et al*. 2006; Druin, 2009). This is evidenced alongside the families' testimonies (throughout the small-scale studies and main study), highlighting their aversions to giving their children constant unsupervised access to screen-based technologies for communication due to the safety and cost.

The Trace Communication System shows how collaborative design experiences, such as co-design, co-creation and participatory design, can be used to increase intimacy in family communication systems. Family participation (collaborative design experiences) at each key stage of the design process (planning, acting, observing and reflecting) increased the child's attachment to their communication objects (toys), within the Trace Communication System.

Strengths:

> ***Co-designing with the users*** was a major asset and strength within this research, as it meant the prototype communication system designed by the families was readily accepted, for the most part, and was in line with what they wanted from a communication system and communication objects. It also allowed for good relationship building and trust to form between the researcher and the families, which led to more honest and frank discussions in the diaries and through the

follow-up interviews about the Trace Communication System.

This method of working allowed the researcher to work with vulnerable user groups (children), looking at sensitive subject matters (separation due to work, illness or family breakdown).

Outsourcing for technical experience and skills (working across disciplines and with other designers). Outsourcing allowed for fully working prototypes, robust enough to leave with participants for prolonged periods of user testing, which offered the varied functionality desired by the families.

Identified methods that are successful in family research:

Co-Design Workshops

Interviews and Discussions - informal and relaxed through making activities within workshops, user testing and in follow up dialogs.

Ethical Framework - ensuring that a clear ethical framework is followed.

De-briefing - offering the family participants closure on the project to ensure no harm comes to them when the project ends.

Limitations:

Families were mostly British; thus, results cannot be generalised to families within other cultures or countries. It is therefore unknown if culture would have any influence on the findings because culture was not a key factor in this research.

All children were female, and three out of the four parents were female. It would be interesting to see how male children responded and interacted. Is there a difference in needs depending on gender? If there is a difference at what age do they occur?

Affordable technology was and unstable at times (due to size). Due to cost and the technology available at the time of creation (2013/14), the Trace Communication

System child's objects (soft toys) were very large. This worked well for the younger children, but there was no scope to make these smaller and more portable for the older children. They were also not fully washable (the technology elements had to be removed before washing).

Outsourcing for technical experience and skills (working across disciplines and with other designers). This, as well as being a positive, was also a negative; as has been discussed before, it is challenging at times to find a synchronous thought process with external contractors who have not been immersed in the research or worked directly with the families to deliver the exact criteria required. Especially when the technology and materials they are working with are new or they are being challenged to use them in a way that they have not done before.

Short testing phases. Due to the short testing phases it was difficult to gain conclusive results on acceptance and prolonged emotional attachment when using the Trace Communication System.

Summary of the Main Study:

The Trace Project's intention was not to develop a fully resolved family communication system for commercial use. Revisiting the aims, they were as follows:

1. To explore the potential of wearable technologies and smart textiles within family communication systems.

2. To explore the integration of intimacy, within family communication systems through play.

3. To explore the potential of disparate but connected communication objects within family communication systems.

This Trace Project has fulfilled these aims proving that there is a need for soft two-way portable communication objects and systems for use within parent and child 'long distance' relationships. The Trace Project offers a blueprint in terms of the methods and tools used to engage and create these new types of intimate portable communication objects. User participation is hugely important, and the Trace Project shows how a co-design process can be utilised with families, to determine the individual needs of each family member for use in their own individual communication object. This inclusive design process was paramount to the success of the final communication system and proved to be especially successful for the children's communication objects, as shown throughout this chapter.

The Trace Project has highlighted the importance of tailored communication objects in keeping with the individual's unique situations, wants and desires when designing a new mode of communication. This was proved to be especially important for children for the acceptance and adoption of a new product. The Trace Project has shown that engagement and connection with, and through, the communication objects, for the children, was dramatically reduced when the initial reaction was not favourable. While the children who felt disappointment in their communication objects, as their initial reaction, still used their communication objects, they did not engage or show the same level of connection to their parents through using the Trace Communication System. This was evident through the number of interactions they displayed, how many times they initiated contact, the number of entries in their diaries (averaging at 7 even though they are older than the younger children whose average was 19, see appendix 4.6), as well as their level of engagement and comments during the final interviews. They were very open about the fact that while they enjoyed some of the features they were not happy with the aesthetic or size of their toys, stating:

> "*I liked that I could call Mummy and see her so the phone in the house was cool, but I didn't like the toy… it is ugly and I can draw better than that*" (Child B, 2014).

"*It's so ugly"* (Child F, 2014).

"It's massive… it's like a baby toy… it doesn't fit in my school bag" (Child B, 2014).

Whilst the younger children who readily accepted their toys and loved their aesthetic, offered feedback such as:

"*I love, love, love Pinkie, he's my second-best friend, Daddy and Mummy and ***** is my first best, yes I love him"* (Child A, 2014).

"He is so soft and fluffy… I like to cuddle him" (Child A, 2014).
"It's so cool, I made that" (Child C, 2014).

"My toy makes me happy" (Child D, 2014).

The Trace Communication System offered families a way to communicate that considered individual needs of communication and catered for these accordingly. This was done by the disparate nature of the personalised intimate portable communication objects created, which offered both synchronous and asynchronous timings of communications and inputs/outputs.

These modes of communication have been shown throughout the research to be the optimum modes of communication objects and systems for use in families with young children. One parent even commented that while the communication system was not perfect it offered the whole family "*a time and space to really consider how they communicate*". (Parent, 2014), if these communications were working in terms of the mode, perceived intimacy, length of the communication and the time delay aspect, stating:

"*This project* (the Trace Project) *let us understand one another better, you know, I had never really thought about how they* (her children) *did not have direct access to me or their dad, I never thought it was an issue, but ***** seems so happy and excited to be using this, that she can actually communicate with her dad and not wait for me to relay messages. I*

wish we could have something like this all the time. We are going to try to connect in different ways from now on, not just through a quick text message to each other (her and her partner) *but to try and find a way to include the kids too, you know, as we really should include them more and reach out to them more when we can't be with each other. You feel guilty, you know, when we are at work and not with the kids, it is so busy sometimes, but the Trace Communication System really gave us a quick and easy way to touch base with each other, it was fun and allowed the kids to have their say*" (Parent 1, 2014).

The Trace project, created intimacy through both the design and the use of the Trace communication system. This was proven by the participants sayings, doings and relatings, through user testing and de-briefing interviews by coding and analysing the data.

Through the design of the system the families worked together using worksheets, drawings and making to support their thinking and uncover latent needs. This process used the idea of construction play to understand and start to solve the problem, so this idea of thinking through making. By working through the problem as a family unit and being co-designers of the Trace communication system created a level of attachment with the system itself. It gave the families experience of a situation where they worked together to create a positive change within the way in which they communicate.

Whilst through the user testing of the Trace communication system, Attachment (the bond between parent and child), was supported, because they were communicating in ways that suited their individual communication needs. A close pattern of interaction was achieved through the types of interactions that were created within the system. These interactions were tailored to the parents and children's needs, from the information drawn from the first two phases within the trace project, understanding and activities.

Symbols were used such as the happy and sad messaged and the secret message for easy understanding and communicating of emotions and intimacy. These very simple interactions ensured that the meaning did not get lost in the remote communication of the messages.

Thus, levels of intimacy were proven with families saying things like it gave them a real connection to one another, they could connect throughout the day more easily, and that there was more of a balance to their interactions, in that both parent or child could initiate the communications.

The following types of intimacy were identified within the Trace Communication System through the user testing and de-briefing interviews:

Commitment

"it allowed us to be present more with each other"

"I think they really felt connected and important"

"like we were there with them more"

"we could quickly respond to their happy or sad messages, it made me feel more in touch with them, and I think it made them feel more in touch with us too because they could let us know how they were feeling whenever"

"it was fun to have that direct connection and not have to go through their mum or gran to get to communicate… [laughs] *we felt like spies, like some sort of covert secret mission"*

"It gave us real connection… we were in our own secret club… just for us… no one else allowed… it was special"

Affective intimacy

"It allowed us to share bits of our days and how we were feeling… I could express joy to her happy message by sending her a funny rhyme or song [audio message]*… she would respond with another happy message… it was fun and a totally new way of communicating for us"*

"I liked sending the secret message to her throughout the day, she seemed to like that the most, it was magic and really reinforced the secret club aspect of the system [Trace communication system]*… special… private… just for us"*

"I would send her short updates on my day and she would respond to these with happy or sad faces depending on what I had said… like when I said I had macaroni

cheese for lunch I got a happy face… she likes macaroni… then when I said I would be late home and miss story time, I got a sad one…"

Cognitive intimacy

"it definitely gave me more awareness, I guess, I mean I defiantly thought about her more [child f] throughout the day, like what was she doing and how was she feeling… it gave me a connection to her"

"I felt more responsible… for her wellbeing and happiness… I guess… normally when I drop her at school, or clubs or her dads I pass on that responsibility, I always worry but feel powerless to do anything… you are always relying on someone else to tell you if there are any issues… this way they can tell you directly, it's pretty neat"

"I think it made them think about us more… well maybe not more… maybe differently… they weren't more aware of our time apart… I think they just felt differently about it… that they had more access to us… they were in more control I guess… I think it helped"

Mutuality

"I think I looked forward to seeing little happy messages on my phone just as much as she enjoyed the secret message or me sending her [audio] *messages"*

"it really balanced the power when it came to communication, I mean we had to wait until they skyped us before we could actually speak to them [laughs] *it was a more playful way to communicate"*

"it was lovely that we could have small exchanges throughout the day… it let them lead some of the interactions… it became more even…"

"it really is amazing how a four year old can take charge of a conversation at a distance… it really brightened up my day to receive messages and calls from her… I know it made her happy too… she wants something similar we can use all the time"

The Trace Project has shown that technology can be used for intimate communication if used in a way that suits the communication needs of the individuals. Technology is becoming a large part of everyone's daily lives and its presence and our reliance on it will continue to snowball during the coming decade and beyond. It is important for everyone's mental health and wellbeing that technology does not take over, that we can learn to use it

in thoughtful and intimate ways, especially when communicating with loved ones.

Parents accept that children cannot and should not be happy all the time. They need to be able to grow, learn to share and understand that they cannot have everything they want such as toys, treats and expensive outings whenever they want them. However, it is important for children to be able to reach out and communicate their feelings of sadness and frustration and have their emotional needs met swiftly to maintain their emotional wellbeing and relationships with their parents.

Figure 5.34 Trace toy hands

As humans grow from childhood into adulthood their basic needs change and they can manage separation more effectively as their rational brain develops. It is, however, very difficult for young children, who often do not understand the reasoning behind the separation, and this can therefore lead to abandonment issues, behavioural issues and or anxiety. Of course, this does not happen in all cases, but it is vitally important to offer children a way to communicate with the people who are central to their world and whom they rely on for emotional reassurance at such a young age.

The Trace Project offers a foundation for future work into the research and development of soft two-way portable communication objects for use in parent and child relationships. It has highlighted the need for a co-design process during the creation of a successful communication system and demonstrated the need for the system have disparate objects that offer both synchronous and asynchronous communications.

Figure 5.35 Trace Communication System (User Testing)

CHAPTER 6: Conclusions, Contributions to Knowledge, and Future Directions

> *"No technology will replace the joy of a bedtime story read from a battery free book by a loving parent."*
>
> (Buckleitner, 2009, p59)

6.1 Overview

Parents and children are, at times, separated due to reasons such as work travel, divorce, and illness, as explored in this thesis, as well as other reasons such as military deployment, incarceration, and immigration. Whether parents are remote or local, they all face separation at times from their children. Parent-child relationships are physical and established through care and play activities. Thus, family separation, whether short or long term, offers many challenges in forming and maintaining relationships.

This thesis recognises the role communication technologies play within family communication. This has been achieved through the co-design of a family communication system (the Trace communication system), which was used by the families, to address some of their communication needs when apart.

Thus, through a participatory action research methodology, utilising inclusive methods such as co-design, co-creation, and participatory design, it is possible to create family communication systems that will effectively support family communication needs, such as intimacy and play, through the modes of communications chosen. Thus, these methods can be applied to future projects, in similar areas of social research using wearable technologies and smart textiles. Particularly in relation to how two objects can communicate or link together or how a physical object can have an online presence, what that is, what it means and how it can affect our everyday lives by making positive changes.

The Internet of Soft Things Project (2015) for example uses similar co-design methods and understands the importance and significance of making, along with the appeal that soft textiles bring to the user. During the workshops the participants or co-designers share information with each other. This is very important as the Internet of Soft Things Project (2015) works with individuals from the mental health community who do not use or trust online technology. There are commonalities with how the participant families within this research felt, especially when parents considered allowing their children independent access to online and mobile communication technologies. Parents do not trust the safety and security of these technologies, and many are too complicated for young children to use independently.

The research discussed within this thesis speaks to a mobile HCI community and also has application within textile design and research due to the use of smart and traditional textiles. It expands the rationale for using inclusive methodologies and methods to continue the growth of smart textile and wearable technology research. Supporting the transition of textiles from 'traditional' to 'smart' allowing smart textile research to evolve past a 'DIY maker culture' and become a 'serious research agenda'. As smart textiles continue to be recognised for their potential within areas such as 21st Century communication, physical health monitoring and wellbeing, design research has and will continue to explore ways in which they can be used to enhance or enrich our lives.

6.2 The Realisation of the Aims, Objectives and Research Questions

Research Aims:

1. To explore the potential of wearables and smart textiles within family communication systems.

2. To explore the integration of intimacy, within family communication systems through play.

3. To explore the potential of disparate but connected communication objects within family communication systems.

Research Objectives:

1. To facilitate intimacy through family communication systems using wearable technologies and smart textiles.

2. To identify suitable methodologies and methods to be used within family research.

3. To develop recommendations for modes of communication and communication objects within family communication systems.

The aims and objectives at the start of the research were to create and evaluate 21st Century family communication systems that would allow families to have equality within their communications, offering children (aged 4-8) more control over their everyday communications with their parents, fostering intimacy both through the design and use of the textile objects produced. These have been achieved and described in Chapters Four (Small-scale studies) and Five (Main Study) through the inclusive and participatory nature of the research. The research aims and objectives regarding play, intimacy, and method choice were addressed through the literature review (Chapter 2) and empirical research presented in Chapter Three (Methodology). The conclusions reached within these theoretical investigations (Chapter 4 and Chapter 5) are presented in this chapter as a valuable foundation of a larger holistic methodology relevant to the evolving and emerging communities of practice within smart textiles and wearable technologies.

Research Questions:

RQ1: Can wearables and smart textiles aid intimacy within family communication systems?

RQ2: What is the role of co-design in the understanding and creation of such a system?

Main Findings:

The literature (Chapter 2) suggests that to be intimately connected, communications must understand and fulfil everyone's communication needs, as well as the emotional and/or factual data families require to feel connected. It was found through the research (Chapter 4 and Chapter 5), that intimate communications can be achieved through the modes of communications (disparate communication objects that offer synchronous and asynchronous communications) found within family communication objects and systems as well as how these systems are designed (through the process of co-design and play).

The Trace project provides a proven set of methods, such as interviews (both interview guide style and informal conversational interviews), generative toolkits within co-design workshops (which followed the say, do, make framework), experience user testing and diary studies, that can be used as a process for the creation of mediated intimacy in family communication systems.

The chosen methodology (Participatory Action Research), enabled the Trace Communication System to be fully co-designed with the families, who were also participant researchers in the study. Thus, the research offers a participatory and inclusive based methodology for the development of wearable and smart textile communication objects for 21st Century family communications. It provides a theoretical framework for future work exploring play and intimacy through physical making and community experiences.

The methodology includes the following primary parts:

- A theoretical framework for using Play in family design research to create engagement within a co-design process.
- An analysis of the say, do, make model as a process of embodying intimacy in 21st Century Family Communication objects and systems.
- Working physical prototypes developed as intimate family communication objects.

The methodology allowed, both the researcher and the participants (families) to gather information, analyse, reflect and iterate at each of the five stages within the Trace project.

Table 6.1 Types of intimacy achieved by the functions of the Trace Communication System

	FUNCTION OF SYSTEM (COMMUNICATION TYPE)	TYPE OF INTIMACY ACHIEVED THROUGH COMMUNICATION
SMART TEXTILE	- Thermochromic ink and heat pad (Secret message)	- Commitment / Affective intimacy
TECHNOLOGY	- Proximity sensor (location sensing of toy)	- Cognitive
	- Haptic feedback switches – toys hands (happy / sad messages)	- Affective intimacy
	- Haptic feedback switch – toys mouth (initiates Skype call)	- Mutuality
	- Projector (on mobile phone) (projects Skype call onto ceiling or wall)	- Commitment / Affective intimacy
	- Audio Recorder (on mobile phone) and Speaker (on toy) (audio messages)	- Commitment / Affective intimacy

Table 6.1 Types of intimacy achieved by the functions of the Trace Communication System

This offered a greater understanding of the families within the Trace project, and allowed for continuous iteration, of the problem through each of the co-design workshops, through user-testing and finally through reflection.

The resulting disparate Trace communication objects (toy and app) were tailored to the emotional needs of each family member (parent and child). This was found to be especially important for safeguarding family intimacy and connection with each family member seeking very different levels of intimacy, connection and information. The children sought fun interactions based on care and play activities with their parents directly (i.e. emotional responses and reactions about their daily routines, interactions with others and how they felt about certain situations), while parents required information about their child's safety, general happiness, and wellbeing, but did not necessarily require real time contact. Intimacy was achieved through the Trace Communication System through the functionality and the design features of both the technology and the textiles as displayed in table 6.1.

6.3 Contributions to Knowledge

The main contributions of this research focus on soft textile-based communications, looking towards smart textiles and wearable technologies and how these 'new' textiles can be leveraged to support us in areas such as communication, health and wellbeing, specifically within parent – child communication. This research advances how soft textile-based objects can be used to support intimate family communications, offering up questions and reasoning's for future research within the mobile HCI community. It draws upon and contributes to scholarly literature that is concerned with communication devices for children, allowing children (aged 4-8) to communicate easily and safely through communication technologies due to the accessibility of smart textiles and wearable technologies. Finally, this research offers a statement for modes of communications, that can be used to enable the design of successful intimate family communication systems (Section 6.2.1 and 6.2.2).

1. The literature (Chapter 2) has shown that there is a need for non-screen based and ad hoc communication objects for children to use to independently communicate with their parent whilst apart. That in doing so increases intimacy essential for family bonding. The Trace project contributes to literature concerned with communication devices for children, and further highlights the need for non-screen based, ad-hoc, and asynchronous communication objects within family communication systems.

   The Trace family communication system enabled the participant families to communicate either in real time (synchronous communications) through the Skype calling feature (initiated by the child) or asynchronous (delayed response time), such as the happy/sad messages, in addition to the different communication objects (disparate).

   This research has shown that there is a distinct need for promoting (instead of negating), human intimacy and connectedness using intimate communication objects instilled with portable technologies and smart textiles. These communication systems are positive reinforcement tools for connecting users, not convenient modes of data transmission.

2. This research observed how family communication systems can create intimacy, by the way in which the information (words, images and sound) are shared though the input and output methods of the communication system. These input and output methods can either be different, i.e. touch in - visual out, or the same, i.e. sound in - sound out.

3. The research discussed within this thesis offers a current foundation of successful modes of communications (see table 6.2 and 6.3), for family communication systems, that supports intimate family communication, through disparate objects.

   Face-to-face communication (physical co-presence) was found to be the most

successful and preferred method of communication in family communications, due to the intimacy created by its multimodality and physicality. However, physical co-presence is not always possible as was revealed throughout this thesis. Thus, new modes of remote communication were sought to create intimacy through family communication systems through virtual co-presence, proxy co-presence, and imagined co-presence. Findings from the small-scale and main study indicate possible alternatives when face-to-face communication is not possible (Chapter 4 and appendix 3).

Thus, the optimum family communication system would be multimodal, enabling parent and child to communicate in real-time, through disparate communication objects which offered both the same and different input and output methods (Table 6.1). This is evidenced through the families' doings and sayings, through the frequency of use of the Trace Communication System (see appendix 4.6), and the reflections from the families on using the system, both within their diaries and through interviews (see appendix 4.10).

Table 6.2 Preferred modes of communication for family communication systems

Features	*Plus either:*
1. Disparate Object	4. Same input/output method
2. Synchronous Communications	OR
3. Multimodal	5. Different input/output

Table 6.2 Preferred modes of communication for family communication systems

However, since real-time communications are not always possible due to work commitments, travel and time differences, secondary modes of intimate communication were similarly explored and found to be successful (Section 6.2.2). This is evidenced through the families' doings and sayings, through the frequency of use of the Trace Communication System (see appendix 4.6), and the reflections from the families on using the system, both within their diaries and through interviews (see appendix 4.10).

Table 6.3 Suggested modes of communication for family communication systems

Features	*Plus either:*
1. Disparate Object	*4.* Same input/output
2. Asynchronous Communications	OR
3. Multimodal	*5.* Different input/output

Table 6.3 Suggested modes of communication for family communication systems

In summary, multi-modal, one or two-way soft communication objects that are disparate in object, synchronous in time, and have either the same or different input/output options have been identified as the most successful modes of communication for an intimate, remote communication system for parent and child (table 6.2).

6.4 Future Directions of this Research

Future research needs to consider and address the stability of the technology, the sizing of the children's communication objects, along with usability issues such as easier charging, which would allow the communication systems to be left with families over longer periods of time without external interference from the researcher. This approach would facilitate a more accurate set of results in the connections that were formed and held with the communication objects, and for discovering if these were long lasting and not just a novelty. These more conclusive results would provide further insight into whether co-designed soft textile personal communication objects can offer an intimate communication system compared to that of their screen-based counter parts.

Other factors that would be considered would be: toy construction and selection for user testing, considering strategies to allow for better acceptance from all children, and including older children. This could be achieved through active making by allowing each child to either physically choose each component of the toy and make it through workshops, or via an online tool for selection. Family communication systems could offer families fully customisable kits to create at home or consider toy creations such as Build-A-Bear models (Build-A-Bear, 2017), where key components are readily available for children to choose (i.e. a character, a colour, clothing). This model could be expanded by families selecting interactions that suited their communication needs.

Self-assembly and creation may offer a stronger connection and reaction, especially from the older children whose initial shock at being presented with their communication objects as the disappointment with the representation of what they imagined in their heads was evident. Taking this approach would also allow end users to be able to choose every aspect of their toy and even personalise the communications they wished it to have, through either online resources or in a face-to-face environment. This would give a clear indication of their communication object's aesthetics so there would be no disappointment on receiving them.

This would build on the work and theories of the Internet of Soft things project (Glazzard *et al*., 2015) where the participants were included not only during the design stages and consulted in the making phase (as they had been within the Trace project) but were active

collaborators and designers in the making of the prototypes themselves. It was thought that the complex nature of the communications and objects that were to be produced in the Trace project were too complicated for the participants to be involved with the actual making of the final prototypes, this was especially worrisome in terms of safety and security of the children. Not only for technical issues like who could be contacted and could contact the child, but for physical safety issues such as combustibility if circuits were not wired correctly. However, with the creation of technologies, such as Little Bits (2017), it is possible for children to become active participants in the making process, choosing which interactions they wanted and clicking together.

Larger scale user testing (testing with a wider variety and number of families) would also be required to understand the true value of this type of communication system and how successful it is for remote intimate parent and child communication.

This research offers co-design methods and a methodology for other similar projects, working in the ever-expanding field of wearable technologies, portable technologies, and smart textiles. The methods described here are promising especially in relation to how two objects can communicate or link together or how a physical object can have an online presence, what that is, what it means, and how it can affect our everyday lives by making positive changes.

While this research and the Trace project focus on family relationships, specifically parent and child intimate communications through communication objects and systems, the methodology developed can be used and adapted to suit many similar projects. The Internet for Soft Things Project (2015) for example uses similar co-design methods and understands the importance and significance of making, along with the appeal soft textiles bring to the user. They aim to explore information about sharing through making and co-designing objects at workshops, allowing the participants or co-designers to share information with others, and have others share information with them. This is very important to the Internet of Soft Things Project (2015) as it works with individuals from the mental health community who do not use or trust online technology.

The Trace communication system was a working prototype that explored the main themes discussed at the start of this research (*The 21st Century Family*; Chapter 2, Section 2.2; *Technology Mediated Communication*; Chapter 2 Section 2.6 and *Participatory Action Research*; Chapter 2, Section 2.8 and Chapter 3 *Methodology*). The outcomes of the Trace project emphasise the importance of further exploration and development of family communication systems, that offer disparate communication objects, that can deliver both synchronous and asynchronous communications.

6.5 Reflections on Methodology

Reflections on the methodology are structured as follows:

1. with the community in mind (families) and how they responded to the inclusive nature of the methodology (section 6.5.1)

2. with the researcher in mind (textile practitioner) and how this way of participatory working has changed personal research and design practices (section 6.5.2).

6.5.1 Participatory Action Research in the Community

Participatory Action Research is:

- driven by participants, rather than an outside sponsor, funder or academic
- collaborative at every stage, involving discussion, pooling skills and working together
- intended to result in some action, change or improvement on the issue being researched

For this research I set out to follow a Participatory Action Research Methodology. While the research was participatory in nature aligning with the participatory agenda of the

methodology, it failed to actively change the behaviour of the community. Whilst it contained several iterations of data collection and analysis, each learning and building upon the previous cycle, resulting in a final 'solution', following the key principles of a Participatory Action Research Methodology, it failed to actively change the way in which the this families communicated after the research had ended. While the families who took part within this research (discussed in the thesis and especially within the Trace Project), have a greater understanding of their collective family communication needs, they do not have the tools or the technology available (the Trace communication system), that enabled them to connect intimately to one another whilst apart. Therefore, the methodology did not reach its full intention or potential within the research and is a key limitation to the research. Future research of this type should look at alternate participatory methodologies such as the Participant Centred Approach (Kettley, Kettley, and Bates, 2015), which offers similar approaches to data generation and collection as Participatory Action Research, moving family communication research forward. By introducing small changes within current systems and frameworks that currently exist for communications, will offer families an intermediate step until smart textiles and wearable technologies become a viable affordable solution to family communications.

As the field of smart textiles and wearable technologies continues to grow and expand, family communication systems will become feasible marketable products that have the ability to effect change and intimately connect families whilst apart.

6.5.2 Action Research for Textile Practitioners

As a textile practitioner, the Action Research Methodology was successful. It shifted my practice from *inward looking* (focusing on my own ideas and making to create solutions), to *outward looking* (focusing on the families and their sayings doings and relatings). This enabled me to co-design communication systems, textile objects and interactions, which were drawn from the family participants and their needs and not on personal assumptions of what 21st Century family communication objects and systems should be.

Thus, textile designers, who are looking to combine physical making with social issues, broadening their research, should look to more inclusive methodologies, where the focus is placed on participation and collaboration within the making process, and not solely upon the lone practitioner, their knowledge and skillsets.

6.6 Closing Remarks

Families and the meaning of family will continue to diversify and evolve, with families living separately for many reasons (work travel, illness, divorce, deployment and incarceration). Therefore, we must continue to look for ways that can support the unique communication context that is parent-child communication, securing family bonds and fostering the intimacy that is created through face-to-face communication, when being physically there with each other is not possible.

GLOSSARY

A

Asynchronous Communication - Communications (messages/interactions) happening at different times (not real-time) i.e. text message, email. A communication where an instant response is not always received.

B

Blended (family) - Families made up of biological parents and siblings, step-parents and siblings, as well as extended family i.e. grandparents, aunts, uncles. Childcare providers such as nannies, childminders, nurseries, are starting to fall under this category due to the time children spend in these service providers' care.

Blue Sky Thinking - Coming up with new and unique ideas. Not being constrained to the reality of what is, but imagining what could be.

C

Co-creation - A people centred methodology meaning 'collaborative creation' (Wildevuur and Van Dijk, 2013). Co-creation is generally multidisciplinary in approach, and is used to make designs, products, and services more relevant to the end users. This happens by including them in the design process (through a partnership or dialogue).

Co-design - A sub-set of co-creation; it is a much narrower term and refers specifically to "*collective creativity as it is applied across the whole span of a design process*" (Sanders and Stappers, 2008, p.16).

Co-design Workshops - A place where real world users participate in design activities (i.e. brainstorming, making, blue sky thinking) and design decisions, questioning current ideas surrounding specific topics that are relevant to them and discovering new concepts or solutions to real world problems/design issues.

Cold Communication - Unfeeling, no emotion (no opposite to this in the sense of terminology used within the thesis – it either has emotion or is devoid of it).

Collaborative Design - When designers and non-designers work together to form an act of collective creativity. Can increase user attachment to the artefact created through the process of collaborative design (Ballie, 2014).

Citizen Participation - An umbrella term that encompasses participatory design, co-design, collaborative design, and meta design (Ballie, 2014).

Connectedness - How humans emotionally relate to one another (and how we feel the need to emotionally connect), and how they fit in with society (producing, reproducing, and consuming). Connected design can promote social wellbeing by designing environments and objects that nurture qualities and feelings essential to wellbeing.

Creative Research - An intuitive, practice-based process that has an iterative, and disruptive approach. Normally collaborative, focussing on real world problems with making. Central to the design process, the results are not controlled and often surprising (Collins, 2010).

D

Design Thinking - A methodological approach which combines numerous viewpoints to iteratively solve problems. Design thinking combines empathy (context of problem), and creativity to generate insights and solutions to sole real world problems (Buchanan, 1992 and Brown, 2008 and 2009).

Diary Studies - A method of self-reporting to record in-the-moment behaviours, thoughts, and feelings. Diary studies can also be used as a method of self-reflection (see reflection).

Different Modes of Input - Different methods of input and output, i.e. text in, sound out.

Discussion - Talking about a topic to exchange ideas, feedback on experiences, and discuss design decisions.

Disparate Object - Different device/object/mode(s) of communication tailored to the individuals needs and situations, i.e. with the case of Huggy Pyjamas (Mixed Reality Lab, 2017) where a small doll, the parent's communication object, sends information to the child's pyjamas, which receives the information and acts accordingly.

Domestication Theory - Looks at how new technologies are adopted by users, how they can change the users' behaviour(s), and how feedback of use can inform the next generation of technology (Hertlein, 2012).

E

E-Clothing - Clothing integrated with electronics for aesthetic or performance enhancing purposes.

Emotional Intelligence - To have the ability to identify, understand, and effect the emotions of others (Mayer and Geher, 1996 and Goleman, 1996).

Empathy - To be able to recognise and understand other's emotions. Empathy is "*the ability to understand and share the feelings of another*" (Oxford, 2017). Empathy in design builds trust and relationships with end users. It is an intuitive way to understand people's motivations and needs rather than using assumptions of what these needs may be (Rifkin, 2009).

End User - The ultimate user of a product or service (normally who the product is designed for), however the end user may not be the consumer (who bought the product/service). For example, parents buying a tablet for a child, or a mobile phone for an elderly relative.

Ethnographic Research - Observing and documenting a specific group's behaviours, beliefs, and practices from their own perspective. It is an anthropological method which is generally used within the group's 'home' setting.

Experience Design - Focusses on the quality of the experience between the user and the product or service being designed.

Experience Prototyping - A method for designers to test ideas and products with users, using lo-fi prototyping or simple technologies. The prototype, while not in its final form, simulates for the user how the product may look like or function; allowing for important feedback for the next iteration of design.

External Funding - Funding that is outside the original grant for a body of work. In this case, AHRC funding for the research (PhD) discussed within this thesis.

F

Facilitation Worksheets - Worksheets (prepared by the researcher) which are used in workshops or discussions by the participants, allowing for the generation of information needed for the research project.

G

Generative Toolkits - A kit, normally used in workshop or focus group settings, comprising of objects such as worksheets, pens, paper, scissors, glue, post-it notes, and objects (relevant to the discussion). Materials found within a generative toolkit are tailored to the session and tend to be simple and ambiguous. This allows participants to project their own ideas onto the objects that they make, or that are presented to them for discussion and idea generation.

H

Hard Communication - Pure data, numeric.

I

Intimacy – A feeling of emotional closeness.

L

Lo-fi Prototyping - Using low cost materials generally, paper, cardboard, low cost fabric, blue foam, to embody ideas or aesthetics. Lo-fi prototypes are used as tools of thinking through making (Csiksentmihalyi, 1990), and discussion to work through ideas or problems.

M

Multi-modal - Stimulating 2 or more senses at once.

O

One-way Communication - Information only flows one way i.e. information can flow either out of object or into a communication system.

P

Participatory Design - A process of actively involving all stakeholders in the design process, resulting in the design of better products and services that fulfil the end user's needs.

Preteen - Generally classed as children aged nine to twelve, before the start of puberty and a child's teenage years (age thirteen - nineteen).

Probes - A probe is an instrument that is deployed to find out about the unknown - to hopefully return with useful or interesting data. There is an element of risk in deploying probes; they might fail or bring unexpected results (Hutchison *et al.* 2003).

Prototyping - Used as a dialogue tool in design. An object/space that facilitates conversations and questions between designers/engineers/technologists/users.

Direct feedback can be gained through prototyping on features such as functionality, aesthetics, user experience.

R

Reflection (reflective thinking and practice) - Relating new knowledge to prior understandings, generating new ideas and approaches to research and practice, and applying these to future work. Reflection can include reflective practices such as reflective writing (keeping ***reflective blogs***), analysis, and discussion.

S

Scattered (family) - Families who live apart, short or long term because of situational factors such as family breakdown (i.e. divorce), work travel, illness (parental or child), incarceration, and military deployment.

Smart Materials - Materials which can change their properties, through external stimulus i.e. temperature, UV levels, moisture, electric or magnetic fields, stress or pH.

Social Media - A highly accessible method of web-based social interaction, commonly using user generated content to create shared dialogues between two or more people.

Social Wearables - Wearable devices that can afford us deeper connections to others, and allow us to recognise and augment our behaviour.

Social Wellbeing - How people understand, experience, and value their connections with others. Feelings of trust, belonging and support are integral to positive social wellbeing.

Soft Communication - Tactile and intimate.

Structural Coding - Applies a content-based or conceptual phrase representing a topic of inquiry to a segment of data that relates to a specific research question used to frame the interview (MacQueen, McLellan-Lemal, Bartholow and Milstem, 2008 p 124) The similarly coded segments are then collected together for more detailed coding and analysis.

Synchronous Communication - Communications (messages/interactions) happening in real-time. i.e. instant messenger, phone call and Skype. A communication where an instant response is always received.

Identical modes of Input - Same method of input and output, i.e. text in, text out.

Identical Object - Same devices/object/mode of communication used by both parties within the communication, i.e. mobile phone to mobile phone.

T

Tangible Interaction - How the tangible aspect of an object effects the user, both physically and mentally, through stimulating a physical or emotional response to the interaction.

Technical Experts - People with vast expertise in a certain area. They work on specific parts of projects, advising and completing specialised work. Generally, they have no input into the original research questions or design decisions, but follow specific instructions and work to pre-defined specifications.

Two-way Communication - Information is free flowing i.e. information can flow to and from a communication system

U

Uni-modal - Stimulating one sense.

User Experience Testing - A Subjective process that can change over time. User experience testing researches how users interact with products and services and what their feelings about these are. Due to the subjective nature of user experience testing, questionnaires, interviews, and discussions (subjective user data) should be combined with other methods, such as observations and analysis of interaction with technology (objective user data).

User Generated Content - Any content created by the users (physical or verbal), through prototyping, worksheets, drawings and discussion.

User Testing - Evaluating a product or service by testing it on the intended audience. This offers real insights on how they use the product or service, through how they react to it, use it, and what they say about it.

V

Visualisation - Conveying meaning and ideas through drawing, making or diagrams. A method of displaying information in a more accessible way than pure text.

W

Wearable Technologies - "*Garments with built-in electronics or electronic devices and new materials that enable functions far beyond conventional ranges of applications.*" (Wearable Technologies, 2010).

Y

Young Children - Are defined as aged two to seven years old when discussed within the thesis.

Young People - Are defined as aged seven to twelve years old when discussed within the thesis.

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